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Algal periodicity in certain ponds and streams

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It is a matter of common observation that algal growths may suddenly appear in ponds and streams, persist for a short time, then disappear with equal suddenness. Doubtless many have noticed this in a casual way and wondered why the plant appeared so suddenly, or why it disappeared. In order to answer these questions, or to form even a good opinion of the causes underlying this irregularity, one must study the algal growth in a certain pond or stream at frequent intervals throughout a year or more, noting the different species of algae present, their relative abundance, time of fruiting, etc., and all the external conditions under which the plants are growing at any particular time. These conditions will include amount of light, depth and extent of the body of water, rate of flow and change of water, temperature, amount of mineral matter in the water, cormophytic growth, animal life in the water, and any effect man may have had, as in draining ponds, emptying rubbish, or sewage, etc., into the water.

But little careful and systematic study has been devoted to this subject. Fritsch * ('06) has given the subject some study. In his paper he makes some good suggestions in regard to methods and gives some interesting observations based on a somewhat irregular study.

During April, 1906, the writer began the study of the algae in a small stream flowing across the campus of Indiana University, and in two ponds near Bloomington. This observation extended throughout April, May, and June, 1906. The following

* Fritsch, F. E. Problems in aquatic biology with special reference to the study of algal periodicity. The New Phytologist 5: 150–169. Jl 1906.

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September the work was again taken up, additional ponds and streams added to the number under observation, and continued until August, 1907. Collections were made twice a month, material being taken from several different parts of each pond or stream, both on the surface and on the bottom, placed in separate vials, and brought to the laboratory for identification. This was done to avoid error so far as possible in determining the amount of any particular alga present. In nearly every case when an alga was found in any quantity in one part of a pond, it was found in other parts also.

It was thought best to select a limited number of ponds and streams and study these closely. The ones chosen were selected on account of the variety of conditions they presented and the ease with which they might be reached. Five different ponds and two small streams were under observation. The ponds will be designated as ponds nos. 1, 2, 3, 4, and 5, and the streams as streams nos. 1 and 2.

Pond no. 1 is a small body of water in an old sink-hole depression, the bottom of which has become clogged and partly filled with soil. It is about 40 feet across and 4 feet deep during the greater part of the year. During August and September the water becomes low, leaving the bottom bare in places. The pond is fed mainly by underground water flowing through openings in the limestone, which is near the surface in this region. The depth of the water varies with the season but is not much affected by a single rain. A small amount of surface water flows into it, carrying in some red clay from the surrounding plowed field. The water must be changed frequently, for it never seems to be impure. The pond is on a hill in an open field, so there is no shade. On November 10, there were .006 g. of solid matter in 54 g. of the water, or .00011 per cent. of the water was solid matter. *Typha*, *Alisma*, *Eleocharis*, *Potamogeton*, and *Callitriche* grow in the pond rather abundantly, but the animal life is not very extensive, consisting of a few salamanders, frogs, tadpoles, dragon-fly larvae, and a few smaller forms.

Pond no. 2 is a small, shallow pond, about two feet deep and 50 feet wide, fed by a spring near by. This pond is not subject to much variation in depth of water. The flow from the spring is

sufficient to change the water in a day or so, but since the spillway is just opposite the feedway and the pond is wide compared with its depth, the water is not changed frequently enough to keep it very pure. A drove of cows run to the pond; this adds to the impurities. On October 29 the amount of mineral matter in the water was .013 g. in 42 g. water or .0003 per cent. The pond is in the open, so is not shaded in any way. But few of the higher plants grow here, a few specimens of *Eleocharis* and *Alisma;* a few frogs and tadpoles are found in the pond the greater part of the year and some small catfish and sunfish.

Pond no. 3 is a small body of water about 30 feet by 50 and two feet deep. It is fed by a wet-weather branch during the greater part of the year. During July, August, and September, the pond goes almost dry. The water is not changed very frequently, hence becomes stagnant. It is not shaded. *Eleocharis* plants grow in tufts over a part of the pond, especially when the water is low. On December 17 the water contained .0003 per cent. mineral matter.

Pond no. 4 is a body of water covering three or four acres and is about 20 feet deep in deepest part. It is formed by a levee built across a small valley and is fed by a small stream. The water is comparatively pure and clear. It overflows but occasionally. On November 3, there were .011 g. of solid matter in 40 g. water or .00027 per cent. The pond is practically free from animal life; it has but few of the higher plants growing in it and there is but very scant vegetation on the surrounding hillsides, hence it is not shaded.

Pond no. 5, or the water-works reservoir, consists of two large bodies of water fed by several springs. Each covers several acres and is from 10 to 20 feet deep. During late summer and in the fall the water becomes low, but on the whole the depth of the water is not subject to much variation. The water is pure and clear the greater part of the time. There are very few cormophytes growing in these bodies of water, but there are forests on three sides of one and on two sides of the other. Hence they are somewhat shaded along the edges and humus from the woods is washed down into the ponds, the sloping banks being made rich. On October 17 the water contained .00021 per cent. solid matter. Animal life in the ponds is scant — only a few fish.

Stream no. 1 is a small stream that flows across the University campus. Above the campus it has the characteristics of an ordinary small stream flowing across the country. During the greater part of the year this flows briskly with a considerable volume of comparatively pure water. After the stream enters the campus it is greatly changed. It receives the warm water from the bathing rooms, the refuse from the chemical laboratories, and the sewage from the closets in the university buildings. This part flows the whole year. The conditions of the two parts of this stream being so radically different, it may be considered as two different streams. This stream is shaded but little, has grassy banks, and and but few of the higher plants grow in it. A few frogs are found here, snapping turtles, mancelli, and planarian worms. On October 31 the water in the stream above the campus contained .015 g. solid matter in 40 g. of water, or .0037 per cent.

Stream no. 2 is a small stream of cool, clear, pure water flowing through a wooded valley about one fourth of a mile long. It is fed by the outflow of an underground river. The flow of the stream is rapid and continues throughout the year without much variation, the temperature being very uniform, standing about 12° C. The plant life, aside from the algae, is limited to an aquatic *Porella*, and the only animals found here are a few fish, crayfish, gammari, and planarian worms.

Of all the orders of algae found growing in the ponds and streams under observation the order Conjugatae was the most abundant both in quantity and in distribution. Among the forms of this order, *Spirogyra* was the most abundant. It was found in some quantity in all the ponds and streams except in the pond no. 1.

Several different species of *Spirogyra* were found. However, it was often difficult to determine the species when in vegetative state. But several of the most common forms were seen fruiting at some period. In that stage they could be easily identified. *Spirogyra nitida* was the most abundant form throughout the year, appearing in considerable quantity in all the ponds and streams except ponds nos. 1 and 5 and stream no. 2. This species was most abundant throughout the year in pond no. 3 (FIGURE 1 — chart, pond no. 3). In September it was rather rare, floating and healthy. For the next few weeks there was not much change

except that the growth was slightly more abundant; about November 21 it settled to the bottom and collected around the edges of the pond. At this time a good part appeared unhealthy. On

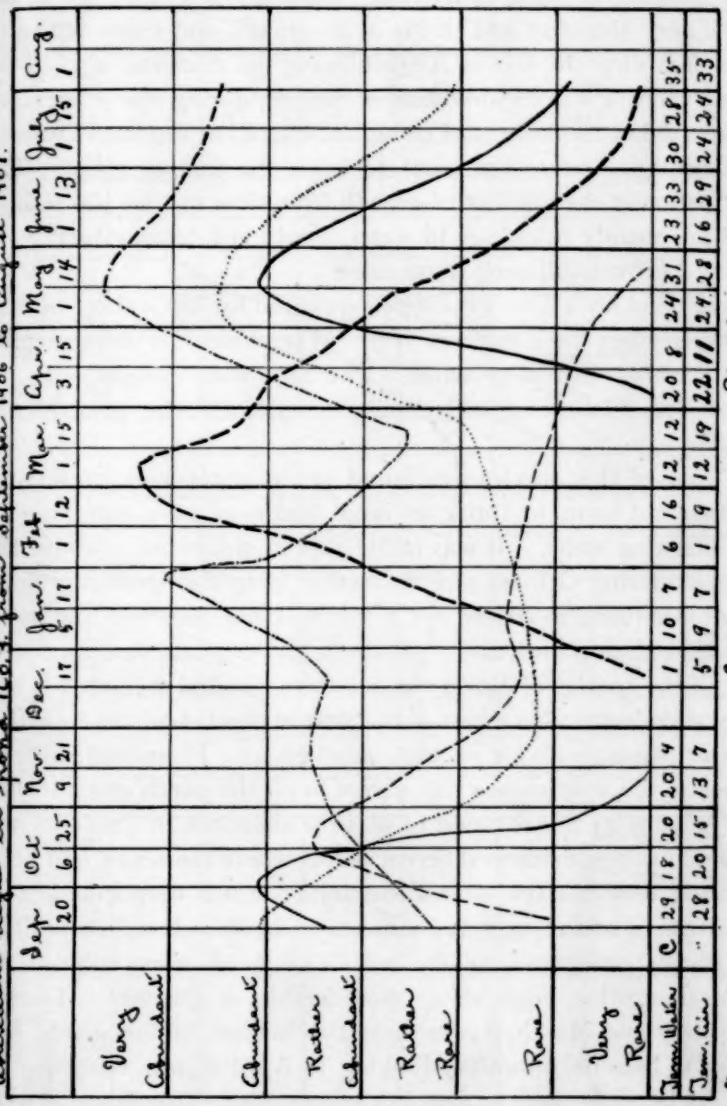


FIGURE 1.

January 5 it had spread out over the bottom of the pond and was dark-green and healthy-looking. It continued to increase in

abundance during the month of January until toward the last, when it began to become more rare and unhealthy. During February and March, the growth became rather rare and unhealthy but showed no signs of fruiting. During April and May, it became very abundant and thrifty in its growth, and continued to be abundant until the first of August, being the dominant alga in the pond. There was no indication of fruiting during the year; conditions did not become hard enough to check the vegetative growth sufficiently to cause the plant to enter the fruiting stage. The fluctuation in the amount of growth from time to time was doubtless due mainly to change in water supply and temperature. Increased growth followed warm rains.

In pond no. 4 *Spirogyra nitida* appeared for but a short time in October when the pond was low. When rains came, the region was covered with deep water. The alga then disappeared. In pond no. 2, a pond with similar conditions, the growth was similar.

None of this species was found in the water-works reservoir. It does not seem to thrive in large bodies of pure water nor in pure flowing water. It was rather rare in stream no. 1 above the campus during October and November, then disappeared. None at all was found in stream no. 2. It was not observed fruiting at any time during the year.

Of the species of *Spirogyra*, *S. varians* ranked second. It was very abundant during a part of the year in ponds nos. 2and 3 and in similar ponds (FIGURE 1 — chart, pond no. 3). From September to January, this species was rather rare in all the ponds and streams. On January 23 it was found to be very abundant in pools on the ground in open fields in different places where the water had been standing several days. On February 12 it was very abundant in ponds no. 2 and no. 3. It continued to be abundant, in a healthy vegetative condition until the middle of April, when it began to look unhealthy, diminishing considerably in quantity. During February and March, it was near the bottom of the ponds, but when it became unhealthy-looking in April it was floating. It has not been observed to fruit in these ponds. That found in wet-weather pools has been observed to begin conjugation every time the pools start to dry up. After each rainy period conjugation

ceased and the plant multiplied rapidly vegetatively until the water began to get low again. This species appeared in stream no. 1 above the campus during October (FIGURE 2—chart, stream no. 1), but

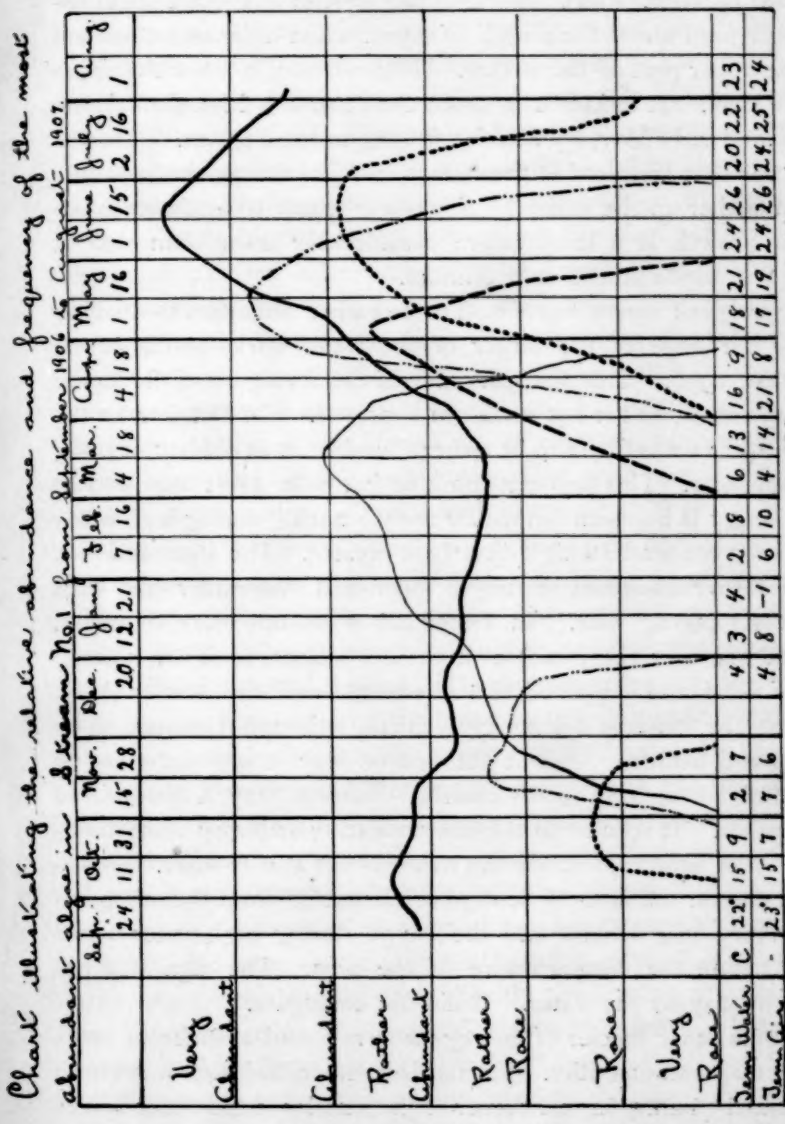


Chart illustrating the relative abundance and frequency of the most abundant algae in 2 streams No. 1 from September 1906 to August 1907.
Very Abundant
Abundant
Rather Abundant
Rather Rare
Rare
Very Rare
Sept. 24
Oct. 11 31
Nov. 15 28
Dec. 20
Jan. 12 21
Feb. 7 16
Mar. 4 18
Apr. 4 18
May 1 16
June 1 15
July 2 16
Aug. 1
Dem. Water C 22° 15 9 2 7 4 3 4 2 8 6 13 16 9 18 21 24 26 24 20 22 23
Temp. Cir. - 23° 15 7 7 6 4 8 -1 6 10 4 14 21 8 17 19 24 26 24 25 24
Clostophora glomerata — Draparnaldia plumosa — Cladophora fracta ——
Spirogyra varians ——— Tolypothrix lubrica ———

FIGURE 2.

was never very abundant. Some was noticed forming spores on November 15. Spores were formed in cells of the filament without

any evidence of conjugation either between cells in the same filament or with cells in another filament. The spores produced resembled zygospores closely. These were likely aplanospores, such as described by West* ('04). None of this species was found after November until about the middle of April, when it became abundant in the upper part of the stream. This was not in a healthy vegetative state. It remained in about the same condition throughout April and early May, not healthy, fruiting to some extent. (Doubtless this that appeared in the stream in April was washed out of a pond farther up the valley.) *S. varians* seems to attain its maximum growth at a temperature considerably lower than that at which *S. nitida* attains its maximum.

Spirogyra crassa was found to be rather abundant in a bayou along the edge of the larger of the water-works ponds during August, 1906. This disappeared with the drying up of the bayou in September, and it has not since appeared. On October 12 the same species was found to be rather abundant in an old bayou along stream no. 1. This bayou is about 10 feet wide, 2 feet deep, and 40 feet long. It has been formed by the "branch" during high water but is not connected with it directly at present. The alga continued to be rather abundant during October and November and in a healthy growing state. In December it became very abundant, spread out over the pond, sank to the bottom, took on a dark-green color and remained very abundant until the first of May. During the winter it did not grow much, although it seemed to be green and healthy. About the first of May, it was not quite so plentiful, nor so healthy as formerly. Later in May, it disappeared altogether. It seemed to become unhealthy and very slimy looking. Just what caused this the writer is not able to state. Possibly a certain amount of sewage or chemicals from the chemical laboratory was washed into the bayou during high water a few days before the disappearance of the alga. The alga was not carried away by the water. It did not conjugate.

Some other species of *Spirogyra* were found at different times but in no great quantities. During December, *S. inflata* was found in limited quantity in one corner of the smaller of the water-works ponds where the water was not very pure. Some decaying vege-

* West, G. S. British Freshwater Algae, 123. 1904.

tation resulting from cormophytic plant growth the previous summer, and the refuse from the pumping station near by, tended to make the water here impure. This was fruiting freely when found and was not found afterward.

Spirogyra Weberi was found in the upper part of stream no. 1 in October in very small quantities and it was rather abundant in pond no. 3 during September and October. It became rare the first of November and disappeared later in the month. No conjugation was noticed although it might have taken place in short time and the whole plant growth disappeared, or it might have been so scattering that it was not noticed, the plant not being very abundant. A few other species were found in small quantities but no attempt was made to follow them in their periodicity.

Among the filamentous forms of Conjugatae, *Zygnema* ranked next to *Spirogyra* in abundance and distribution. It was found in some quantity in several of the ponds but not in great abundance in any case. In stream no. 1, *Zygnema insigne* appeared during October, became rather abundant, then gradually disappeared in November. It was not observed to fruit. On April 18, *Zygnema leiospermum* was found in the upper part of the stream just below a pond in which the species had been growing. It was rather rare, not growing or healthy looking, and was fruiting to some extent. This species continued to be present in small quantities until the first of August. The same species was rather abundant in pond no. 3 during the latter part of September, 1906. It was pale-green and unhealthy looking, and mixed with *Spirogyra*. It became rare during October and disappeared the first of November. A few scattering filaments of *Z. leiospermum* were found in pond no. 2 during November, 1906, and also during the following May. *Z. cruciatum* was found to be rather abundant in pond no. 1, March 14. It was not very healthy in appearance and remained in about the same condition until the latter part of May, when it began to grow, became more healthy, and more abundant. It was along the edge of the pond in shallow water — some of it floating. This disappeared in June.

Mougeotia was not very abundant at any time in the waters under observation. A few species were found in limited quantities. *Mesocarpus radicans* was found on April 4 in small quantity

in the smaller water-works pond, among a growth of *Typha*. It was not seen there again but was found in a water-trough near by, in which there was flowing water. It was rather rare here during April and May, then disappeared. *Mougeotia scalaris* (*Mesocarpus scalaris*) was found in the upper waters of stream no. 1, October 1. It was rather abundant and unhealthy looking and became more rare and unhealthy the latter part of October and in November. None was noticed after November 15 until March 4, when a small amount was found in an unhealthy condition; it did not seem to be growing any and had doubtless passed the winter in that condition. During May it began to grow and again became rather abundant. Following this it became rare but persisted throughout the summer. Small quantities of *Mougeotia parvula* (*Mesocarpus parvulus*) were found in small pools of water in the upper part of stream no. 1 in May. The water here was slightly stagnant, not flowing freely. This was rather abundant in stagnant pools until the first of August.

Another filamentous form of the Conjugatae found was *Mougeotia genuflexa* (*Pleurocarpus mirabilis*). This was rather abundant in the lower part of stream no. 2 during the latter part of October and in November. Many filaments were bent at nearly right angles and the angles were united as if the cells were conjugating but nothing to indicate the passage of cell contents was observed. No spores were seen. On June 3 this plant was found floating in the upper part of the larger of the water-works ponds, near where it was found in stream no. 2. It was rather abundant and not very healthy and seemed to be in an early stage of conjugation similar to that which was seen in November. Later in the summer, this species was found floating in several places in both of the water-works ponds. In every case certain cells were bent as described above and connected with similar cells in other filaments. The plant always appeared to be unhealthy.

Representatives of six genera of the family Desmidiaceae were found but only a few species in each genus — one in some. *Closterium* appeared to be the most abundant, both in quantity and distribution, appearing in four different ponds. *Closterium acerosum* was especially abundant in pond no. 2. Here it was noticed October 29, rather rare but in a healthy growing condition. It

became rather abundant during November and December, then, increasing by cell division, it became very abundant in January. During February and March, the plant began to look somewhat unhealthy and was only rather abundant. During April and the first part of May, it again became healthy, grew rapidly, and became very abundant. Later in May, it began to be rare again. Following this, it became very rare and disappeared in June. In pond no. 3, this form was found during the greater part of the year but never in abundance. There was some fluctuation in amount, becoming rather abundant in November, then rare (FIGURE 1 — chart, pond no. 3).

In the upper part of stream no. 1, *Closterium acerosum* was noticed September 24. It was rather abundant, growing among filaments of *Spirogyra*. It became less plentiful during October and disappeared during November. In every case *C. acerosum* was found growing with *Spirogyra*, either among the filaments or on the bottom. Just what caused the fluctuation in the amount of the plant, is not easy to explain. It was probably not due to temperature, for in one instance when most abundant, in January, the temperature was low, 5° C. and in another, in April, it was rather high, 18° C.; it became rare in February under a low temperature, 1° C., and rare in May under a temperature of 26° C. It is doubtful if the animal life of the pond had any bearing on the matter. There were few small animals in the pond that would likely feed on the desmids. The periods of greatest abundance seemed to follow seasons when the water was lower and more impure. This doubtless had some influence on the growth, for in some experiments, to be mentioned later, it was found that if the liquid in which the desmids were growing became more dense, cell-division would be more frequent.

A few specimens of *Closterium Ehrenbergii* were obtained from pond no. 1 during November and also during May. On May 14 a good quantity of this species was found growing among filaments of *Cladophora* in a large glass jar in the University greenhouse. This material was so rich in desmids that thousands of them could be obtained free from impurities by rinsing a small mass of the *Cladophora* in a small vessel of water a moment or two. After obtaining the desmids in this way, they were placed in a large

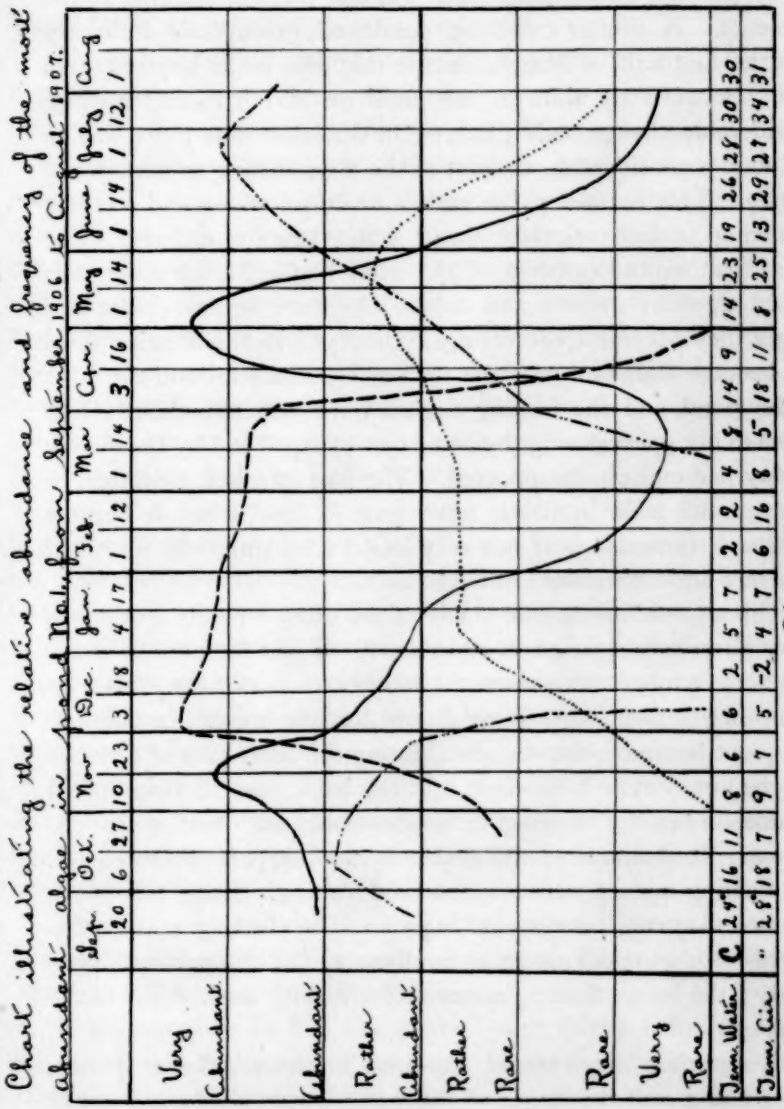
crystallizing dish in which there was a small amount of *Cladophora* growing. By filling the vessel with water every few days the desmids were kept growing for several months and a careful study was made of them. The vessel was kept in the greenhouse where the air was damp and the temperature moderately high and steady. At certain times these desmids were found to divide so as to reproduce themselves vegetatively much more abundantly than at other times. Different causes seemed to induce this. If the water began to get low in the vessel so as to make the solution more dense and richer in salts, division appeared to be more active; if placed on agar saturated with normal culture-solution, they divided more abundantly; if placed in a small crystallizing dish on the oven, so as to change the temperature suddenly to a relatively high temperature, 26° C., in 48 hours, one half of the number were in the process of division. A sudden change, or hard conditions seemed to induce cell-division. The cells that divided on the agar preparation, and the ones that divided in the vessel on the oven did not develop into two healthy, full-sized specimens; the ones in the vessel kept in the greenhouse required from six to eight days after cell-division could be first noticed for the daughter semi-cells to reach full size.

Experiments similar to the above were tried with *Closterium acerosum*, with similar results.

A very few specimens of *Cosmarium* were present in all the ponds and streams throughout the year, but in no case were they found in any abundance. On April 30 a few *Cosmarium* zygospores were found in pond no. 1. *Docidium Trabecula* was rare in pond no. 3 during October and November, and a few specimens were obtained from pond no. 2, January 14. *Hyalotheca* and *Staurastrum* were present in the spillway of pond no. 4 in very small quantities in December. A few specimens of *Penium interruptum* were found in the lower part of stream no. 1 during June, 1907. This species appeared in the water-works reservoir about the same time.

The Oedogoniales ranked second in abundance, considering quantity, and they were rather generally distributed in the ponds and streams under observation. *Oedogonium* and *Bulbochaete*, representing the two genera in the family Oedogoniaceae, were found, *Oedogonium* being quite common and *Bulbochaete* rather rare.

Oedogonium crassiusculum was abundant and the dominant alga in pond no. 1, September 20 (FIGURE 3 — chart, pond no. 1.) It was mostly attached to dead *Typha* stems and other stems under water.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May 1 14
June 1 14
July 1 12
Aug 1
Dem. Water C 24 16 11 5 6 6 2 5 7 2 2 4 5 14 9 14 23 19 26 25 30 30
Dem. Cir. " 25 18 7 9 7 5 -2 4 7 6 16 8 5 18 11 5 25 13 29 27 34 31
Oedogonium crassiusculum
Cleistophora pinifermis
Vaucheria geminata
Peridineae gigas

FIGURE 3.

A few filaments were fruiting. It became more abundant during October, continuing to fruit to some extent. In November it be-

came more healthy and thrifty looking and fruiting filaments became rare. During December and January, the plant was rather abundant in sort of a resting state — not growing any, living, but crusty looking, due to particles of soil and diatoms clinging to the filaments. A similar condition continued throughout February and the first half of March, except that the plant became more rare. Between my visits to the pond on March 14 and April 3, considerable change took place. On the latter date there was in the pond a considerable amount of the alga floating in unattached masses. This seemed to be rather healthy looking and was just beginning to fruit sexually, dwarf males being numerous. The warm weather and sunshine of the latter half of March must have caused vigorous growth and as the filaments became older and longer they became free-floating. On April 16 this floating form had become abundant near the surface, especially around the edge of the pond, and the fruiting organs were very abundant. This began to disappear during the latter part of April and by the middle of May had entirely disappeared. The part attached continued to be about the same until the latter part of May, when it became more rare, brownish and not very healthy looking. It remained very rare and unhealthy until August.

This alga did not appear in any of the other streams and ponds under observation except in pond no. 2. It was found to be abundant here October 11 — scattered all over the pond, some attached to *Eleocharis* and *Potamogeton* plants but the most free-floating. The plant became more abundant during the latter part of October and the first part of November. In the latter part of November it became unhealthy looking, less abundant, and settled to the bottom. It disappeared altogether in the first part of December. The floating masses were not observed fruiting. Some few of the attached filaments bore sexual organs. The floating masses appeared here as suddenly as in pond no 1. It disappeared more slowly; the loose, floating masses were mainly washed out of the pond.

Oedogonium cryptoporum appeared in three different ponds, nos. 3 and 4 and the larger of the water-works ponds, but not in much abundance in any one. A small amount was found in September, October, and the first part of November. Later in

November it disappeared, not appearing again until the middle of the following April. It then became rather abundant, reaching its maximum in the first half of May. On May 18 it was fruiting abundantly. About the first of June, it had become very rare in most places, entirely disappearing in some.

The causes of this periodicity of *Oedogonium* are not easy to explain; only a few facts can be pointed out that probably had an influence. The increase in the amount of *Oe. crassiusculum* in November was not very great. Doubtless a good portion of this passed the summer in a sort of resting condition — the filaments growing but little — then, when rains came in November, increasing the amount of water in the pond, there was growth. Following this time, the temperature became too low for much growth and the alga became more rare, yet a relatively small amount persisted throughout the winter in a resting state. When heavy rains came in March, accompanied by warm weather, there was a rapid growth for two or three weeks. As the temperature of the water became higher and the light more intense, the alga was caused to pass from a vegetative to a fruiting state and after fruiting it began to disappear rapidly. Klebs* (1896) found in experimenting with *Oedogonium* that increasing the intensity of light would tend to cause an increase in the production of sexual organs.

Bulbochaete crenulata appeared in pond no. 1 about November 23, and persisted during the winter in small quantity, growing but little. About the first of May, it had become slightly more abundant, was growing somewhat, and bearing sexual organs. Later in May it disappeared. On July 31 a small amount was found attached to grass in the upper end of the larger of the water-works ponds. It was in a vegetative state and did not appear to be growing much.

The Chaetophorales were tolerably abundant in the ponds and streams studied and rather generally distributed, the genera *Chaetophora* and *Draparnaldia* being the most abundant.

Representatives of but two genera were found belonging to the family Ulotrichaceae; these were *Ulothrix* and *Stichococcus*. *Ulothrix aequalis* appeared in pond no. 1 about the middle of

* Klebs. Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. 1896.

March, growing with *Vaucheria* and not attached. This was rather healthy and growing for a time. It became rather abundant on the east side of the pond during the latter part of April and the first of May. Then it began to become unhealthy looking, the cells of the filaments coming apart. From this time on it gradually disappeared, none being found June 25. *Ulothrix zonata* appeared in the lower part of stream no. 1 the middle of July. It seemed to be healthy and growing, was a bright-green, with filaments a foot or two long, attached at one end, the other floating. It disappeared in a few weeks. A small amount of *Coleochaete scutata* was found in pond no. 1, July 8, clinging to dead submerged *Typha* stems.

A small amount of *Stichococcus* was found growing on the dry clay soil clinging to the roots of a large tree that had blown down along stream no. 2. The soil was sheltered so that it was usually rather dry. This was first noticed early in the winter. It remained in a growing stage during the entire winter, reaching its maximum abundance in March. During the latter part of May and the first of June, it disappeared. Doubtless the soil became too dry and the temperature too warm.

A limited amount of *Herposteiron* was epiphytic on *Oe. crassiusculum* in pond no. 1 during March and April.

Representatives of three genera belonging to the family Chaetophoraceae were found — *Chaetophora*, *Myxonema*, and *Draparnaldia*. *Chaetophora* was the most abundant, appearing in considerable quantities in pond no. 1 and stream no. 1 (see charts).

Chaetophora pisiformis was rather abundant in pond no. 1, September 20, 1906, appearing as small glistening greenish globules attached to submerged objects. It continued to be rather abundant until the last of November, when it disappeared; appearing again about the middle of March, it spread over the pond and became very abundant in distribution especially, coating nearly everything submerged in the pond. It continued abundant to the first of August, being the dominant alga of the pond the greater part of the time. The same species appeared in the upper part of stream no. 1, November 15. It was abundant for about a month, attached to sticks, grass, and stones on the bottom of the "branch." The masses here seemed to be much larger than

in pond no. 1, as large as a pea, light green and bladder-like. It disappeared the last of December, appearing again the first of April. It became very abundant during the last of April and the first of May — the dominant alga. It began to be more rare the last of May and had entirely disappeared by the last of June. The animal life of the stream doubtless had something to do with its disappearance. There were numerous tadpoles in the "branch" and it was noticed that in pools in which there were many tadpoles there was no *Chaetophora*. The disappearance during the winter was likely due to low temperature.

Chaetophora endiviaefolia was found to be rather abundant, attached to objects on the bottom in the upper part of stream no. 1, November 15, 1906. A little later it became rare, but persisted in small quantities during the winter. In March it began to increase in abundance, becoming very abundant about the middle of April. This continued until about the first of June, when it began to disappear. By the last of June, it had entirely disappeared. This species was doubtless affected by the same agencies as the preceding form.

Draparnaldia plumosa appeared in the upper part of stream no. 1 about the middle of November, 1906 (see chart). It seemed to be healthy and growing. It varied in abundance during the winter, being usually rather rare or rather abundant. Floods washed away large quantities, making it rather rare at times. Material brought into the laboratory on February 16 showed numerous zoöspores in 24 hours. This plant reached its greatest abundance in March. After this it began to disappear and by the last of April had disappeared altogether. This plant appeared in several other places, but in every case the conditions were very similar. It seems to thrive in flowing surface-water at a temperature ranging from 0° to 15° C. In no case was the plant found in a pond.

Two species of *Myxonema* were found, *tenue* and *nanum*. *M. nanum* persisted throughout the year without change on wet rocks at outlet of sewer on campus. The conditions under which it was growing were not subject to much change, the water being warm continually, about the same in amount and always richly laden with sewage. *Myxonema tenue* was first noticed in the lower part of stream no. 1 April 18. The filaments were attached at one end,

floating in long ribbons. Material brought into the laboratory produced numerous zoöspores in a few hours. This form persisted until the first of August, becoming rather rare at times.

The only species found belonging to the order Cladophorales was *Cladophora glomerata*. This species was present in the upper part of stream no. 1 (see chart) throughout the year. During only a few months in the spring, ranging from the middle of April to the middle of June, was there much growth. During this time it grew rapidly so as nearly to fill the channel of the stream. Its growth was checked at the end of this time, doubtless by the water becoming low, impure, and warm. During the rest of the year the filaments that persisted were unhealthy looking, the cells had thick walls and were crusty looking, due to particles of sand and diatoms clinging to them. It was noticed in several places that where the plant grew in swift water the filaments were much branched; in quiet flowing water there was but little branching. *Cladophora* was not found in a healthy growing state in any of the ponds. Small masses were found in some, but it was not in a healthy condition and had doubtless floated in from a feeding branch. *Cladophora glomerata* transferred from stream no. 1 to stream no. 2 and anchored in the latter failed to grow. This stream has purer water, flows swiftly and has a relatively lower temperature than the first, standing at about 12° C. continually.

The only representatives of the order Siphonales found in the regions studied were two species of *Vaucheria*, *V. sessilis* and *V. geminata*, var. *racemosa*. *V. sessilis* was very abundant on the damp, sloping banks all around the larger of the water-works ponds October 4. It continued to be abundant and healthy, growing vegetatively until the first of November, when it began to bear sexual organs. It was fruiting considerably the middle of November. On the fourth of December it was looking yellowish, unhealthy, and seemed to be loosened from the ground, due to the ground freezing and thawing. On December 21, the ground was covered with snow, but in places small patches of *Vaucheria* could be seen, unhealthy in appearance. Ripe oöspores were found in it. They were no doubt "seed" for next year's crop. On January 10 the banks were in the main covered with water due to a rise in the pond, and no *Vaucheria* was to be seen. It did not reappear before the close of the study, the first of August.

Vaucheria geminata var. *racemosa* was found in pond no. 1, October 6 (see chart). It was rather rare, growing in shallow water and fruiting somewhat. During the first of November the pond dried up in parts, but the *Vaucheria* continued to grow freely, forming a dense felt over the rich damp earth on the bottom of the pond. On November 23 this was covered with about a foot of water. The submerged *Vaucheria* showed some signs of decay. It remained in about the same condition, unhealthy looking until the twelfth of February, when it was found that the old filaments were covered with fruiting organs. Some of the felts remained attached to the bottom, while others loosened and floated around. They persisted until the last of March, when the filaments turned black and decayed. The pond is surely well sown with spores. The change in conditions due to the flooding with water more than likely caused the formation of the reproductive organs. An aquatic form grew throughout the year in stream no. 2 near the spring. Here there was but little variation in the condition, quantity, or temperature of the water. There was no change in the alga. No sexual organs were produced. This seems to show that under steady favorable conditions an alga continues in a healthy, growing, vegetative state continually. It was not possible to determine the species of this alga.

Numerous representatives of the order Protococcales were found but they were nearly all found only occasionally and in very small quantities. On account of this we will pass by all of them except *Tetraspora* with a mere mention at the end of this sketch. *Tetraspora lubrica* began to appear in the upper part of stream no. 1 the first of March (see chart). It increased in abundance until the first of May, when it reached its maximum. By the end of May, it had disappeared. This alga seems to thrive in "branch"- or surface-water when flowing freely and at a temperature from 5° to 20° C. Certain other colonial forms belonging to the same order, *Gonium*, *Pandorina*, *Pediastrum*, *Coelastrum*, and *Scenedemus*, appeared in the more stagnant pools of the upper part of stream no. 1 during June and July, 1907.

A number of species of Bacillariales were observed but no effort was made to classify them or trace their periodicity.

The Cyanophyceae were not very plentiful in the regions

studied except in two places, the smaller of the water-works ponds and in the lower part of stream no. 1. This class of plants seems to thrive best in impure water. The water-works pond just mentioned, taken as a whole, contains relatively pure water, but at one corner near the pumping station it was very impure, due to the oil and refuse from the pumping station flowing into it. Here there was always a good amount of the Cyanophyceae to be found growing. From this place they floated out and settled around the edge of the whole pond.

Two species of *Nostoc* appeared in the territory studied, *N. verrucosum* and *N. commune*. *N. verrucosum* persisted throughout the year in stream no. 1 with very little change. At times it appeared to be less abundant but this was due to the water washing away a part during floods. It was attached to the stone bottom of the "branch" in the swifter parts. It grew up in hollow subglobular masses five or six centimeters in diameter. They were at first pale yellowish-green, rather firm, jelly-like masses, but the outer part soon became incrusted with lime so as to make it harsh and crusty. Soon after reaching this stage the flow of the water caused them to break loose and float away. No heterocysts or spores were noticed.

A small amount of *N. commune* was found growing on the damp soil along the edge of pond no. 3, September 20, 1906. The region was covered with water at my next visit and none of the alga was found. The same species was found growing in a similar place along the upper part of stream no. 1, October 11. It continued to grow here and was rather abundant until the middle of November, when it disappeared.

Scattering filaments of *Anabaena* were found at various times during the year in material collected in the lower part of stream no. 1, pond no. 1 and the smaller of the water-works ponds, but no attempt was made to trace the periodicity.

Three different species of *Oscillatoria* appeared in considerable abundance in the ponds and streams under observation. These were *Oscillatoria tenuis*, *O. limosa* and *O. princeps*. Some other species were noticed but they did not persist any length of time. *O. tenuis* was the most abundant form both in quantity and distribution. It was abundant in stream no. 1, especially in the

lower part, and in the smaller of the water-works ponds during the greater part of the year. In stream no. 1 it grew on the stones in the bottom, forming a tolerably dense stratum. A similar stratum formed on the rocks at the outlet of pond no. 4 whenever sufficient water flowed over the spillway to keep them wet. Around the edge of the smaller of the water-works ponds there was usually a stratum covering the bottom in the shallow water. Whenever sufficient oxygen collected in the meshes of a mass it was loosened and floated on the surface.

Oscillatoria princeps (*O. Imperator* Wood) was found to be rather abundant in the most stagnant part of the smaller of the water-works ponds during the latter part of September, October, and the first of November, 1906. It appeared again the first of June, 1907, and continued to be rather abundant until August. It appeared also in ponds nos. 2 and 3, going through a similar periodicity.

Oscillatoria limosa (*O. Froelichii* Kütz.) appeared in all the ponds and streams except pond no. 1 and stream no. 2, being especially abundant in pond no. 2 and stream no. 1 from December to the first of May. It seems to thrive well in foul water. It seemed to become more abundant in pond no. 2 when there was considerable cow-manure around the edge of the pond. Cattle had access to the pond only a part of the time.

Calothrix parietina (*Isactis caespitosa* Wolle) was abundant on the stones in the bottom of stream no. 2 the entire year, changing but very little. The conditions under which it grew were unchangeable.

CONCLUSIONS *

An alga growing under steady normal conditions continues, in the region studied, to grow in a healthy vegetative state throughout the year. *Nostoc verrucosum*, *Calothrix parietina*, and the *Vaucheria* growing in stream no. 2 showed this, and also the *Myxonema nanum*, growing at the sewer outlet.

A sudden change in external conditions checks the vegetative growth of an alga and tends to cause it to enter a resting stage form or to fruit sexually.

* For local observers I may state that stream no. 1 is known as Jordan Branch; stream no. 2, Stone Spring Branch; pond no. 1, Hill Pond; pond no. 2, Faris Pond; pond no. 3, Fees Pond; pond no. 4, Monon Pond.

Spirogyra varians is the most widely distributed alga found in this region. It grows under varied conditions. It conjugates at all seasons of the year, depending on hard external conditions, *e. g.*, the drying up of a pond.

Chaetophora thrives best in water slightly stagnant at a temperature from 5° C. to 25° C.

Draparnaldia plumosa thrives in flowing surface-water at a temperature from 1° to 15° C.

Cladophora glomerata grows best in flowing surface-water. It persists throughout the year in the locality studied but is in a growing condition only a few weeks in the spring, while there is a brisk flow of moderately pure water.

Spirogyra nitida is the most abundant of the Conjugatae in the small stagnant ponds about Bloomington.

A CLASSIFIED LIST OF THE ALGAE FOUND, TOGETHER WITH BRIEF DATA ON THE FORMS NOT DISCUSSED ABOVE

CHLOROPHYCEAE

CONJUGATAE

Zygnemaceae

Spirogyra Link

nitida (Dillw.) Link

crassa Kütz.

varians (Hass.) Kütz.

neglecta (Hass.) Kütz. Bayou along lower part of stream no. 1, 11 Je to 1 Au '07.

Weberi Kütz.

inflata (Vauch.) Rabenh.

rivularis Rabenh. Water-works reservoir, 29 Je '07.

Zygnema Kütz.

insigne Kütz.

leiospermum De Bary

cruciatum Ag.

Mougeotia De Bary

genuflexa (Dillw.) Ag. (*Pleurocarpus mirabilis* A. Br.)

scalaris Hass.

parvula Hass.

Desmidiaceae

Closterium Nitsche
Cucumis Ehrenb. Upper part stream no. 1, 27 Je '07.
acerosum (Schrank) Ehrenb.
strigosum Bréb. Pond no. 1, 14 My '07.
Dianae Ehrenb. Pond no. 1, 15 N '06 to 10 F '07.
Ehrenbergii Menegh.
Cosmarium Corda
Botrytis Menegh. Pond no. 2, 23 N '06 to 25 Jl '07.
laeve Rabenh. Pond no. 3, 20 S '06.
pyramidatum Bréb. Water-works reservoir, 10 D '06.
Phaseolus Bréb. Pond no. 4, 8 D '06.
Docidium Bréb.
Trabecula (Ehrenb.) Naeg.
Hyalotheca Ehrenb. sp.
Staurastrum Meyen, sp.
Penium Bréb.
interruptum Bréb.

OEDOGONIALES

Oedogoniaceae

Oedogonium Link
crassiusculum Wittr.
cryptoporum Wittr.
Bulbochaete Ag.
crenulata Pringsh.

CHAETOPHORALES

Herposteiraceae

Herposteiron Naeg. sp.

Coleochaetaceae

Coleochaete Bréb.
scutata Bréb.

Ulotrichaceae

Ulothrix Kütz.
aequalis Kütz.
subtilis Kütz. Stream no. 1, 1 My '07.
zonata (W. & M.) Aresch.
Stichococcus Naeg. sp.

Chaetophoraceae

Chaetophora Schrank
pisiformis (Roth) Ag.
endiviaefolia Ag.
Myxonema Fries
nanum (Dillw.) Hazen
tenue (Ag.) Rabenh.
Draparnaldia Bory
plumosa (Vauch.) Ag.

CLADOPHORALES

Cladophoraceae

Cladophora Kütz.
glomerata (L.) Kütz.

SIPHONALES

Vaucheriaceae

Vaucheria DC.
sessilis (Vauch.) DC.
geminata (Vauch.) DC.

PROTOCOCCALES

Volvocaceae

Gonium Müll.
pectorale Müll. Stream no. 1, 10 Je '07.
Pandorina Bory
Morum (Müll.) Bory. Stream no. 1, 10 Je '07.

Pleurococcaceae

Pleurococcus Menegh.
vulgaris Menegh.

Hydrodictyaceae

Pediastrum Meyen
Boryanum (Turp.) Menegh. Stream no. 4, 10 Je '07.

Protococcaceae

Coelastrum Naeg.
microporum Naeg.
Scenedesmus Meyen
caudatus Corda. 20 Jl '07.
obtusus Meyen. Pond no. 4, 4 D '06.
Nephrocytium Naeg.
Agardhianum Naeg. Upper part stream no. 1, 27 Je '07.

Palmellaceae

Tetraspora Link
lubrica (Roth) Ag.
Gloecystis Ag.
gigas (Kütz) Lagerh. Pond no. 1, N '06 to Au '07.

HETEROKONTAE

CONVERVALES

Tribonemaceae

Ophiocytium Naeg.
bicuspidatum (Borge) Lemm. Pond no. 1, 30 Ap '07.

CYANOPHYCEAE

Nostocaceae

Nostoc Vauch.
verrucosum Vauch.
commune Vauch.
Anabaena Bory, sp.

Oscillatoriaceae

Lyngbya Ag.
ochracea (Roth) Thur. Edge of water-works reservoir, 2 N '06.
Juliana Menegh.
Oscillatoria Vauch.
tenuis Ag.
limosa (Roth) Ag.
princeps Vauch.

Phormidium Kütz.

tenue (Menegh.) Gom. Edge of pond no. 2, 14 My to 26 J '07.

incrustatum cataractorum (Naeg.) Gom. Upper part of stream no. 1, 5 Mr '07 to 1 Au '07.

Arthrospira Stizenb.

Jenneri (Kütz.) Stizenb. Edge of pond no. 4, 29 Je '07.

Rivulariaceae

Calothrix parietina (Naeg.) Thur. (*Isactis caespitosa* Wolle.)

Chroococcaceae

Merismopedia Meyen

convoluta Bréb. Pond no. 2, 27 F '07.

INDIANA UNIVERSITY, BLOOMINGTON,
INDIANA, August 1, 1907.

Some Araucarian remains from the Atlantic coastal plain *

EDWARD W. BERRY

(WITH PLATES 11–16)

The considerable theoretic importance recently assigned to the Araucarieae by some authors, coupled with their abundance and wide range during the Mesozoic and their restriction in modern floras to the South American and Australian areas, renders them a most interesting group of plants, as they are undoubtedly among the most curious and striking in appearance.

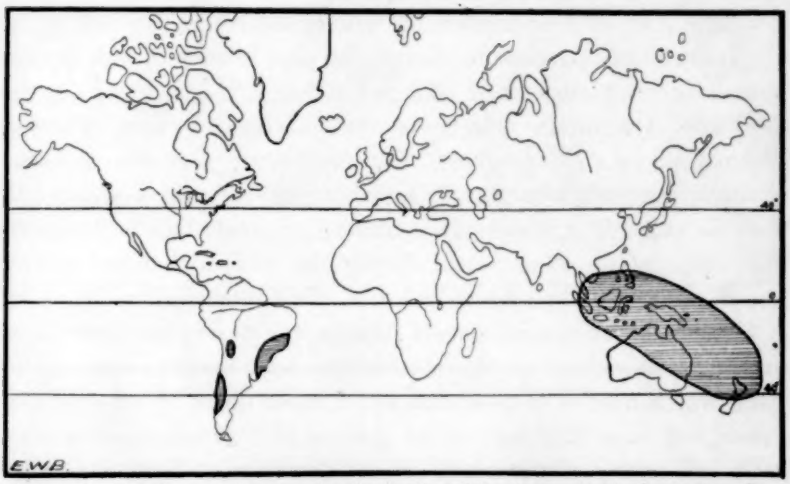

FIGURE 1. Sketch map, showing the distribution of the Araucariae in the modern flora.

The geographical distribution of the recent species is included within the lined areas of FIGURE 1. The wide extension of the oriental area is due chiefly to the genus *Agathis*, which is essentially an island type, ranging from the Philippines to New Zealand. It is to be noted that this genus does not occur in the Western Hemisphere, although during the Cretaceous rather closely allied ancestral forms (*Dammara*, *Protodammara*, and *Dammarites*)

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ranged from Greenland to New Jersey and Montana. Unfortunately, the more familiar generic term for those plants, *Dammara*, is a pre-Linnean name, having been proposed by Rumphius in 1741,* so that recently systematists have taken up the name *Agathis* proposed by Salisbury in 1807.†

The genus *Araucaria* is chiefly oriental, with eight or nine species, all but one belonging to Endlicher's subgenus *Eutacta*, (1847), characterized by more or less acicular, keeled leaves and winged cone-scales. This subgenus is not represented in South America, the two or three species from that continent being referable to the subgenus *Columbea* (Salisbury, 1807), characterized by broad flat leaves, and with one species, *Araucaria Bidwilli*, in the Australian region (the "Bunya-Bunya" of southern Queensland). It will be noted also that North America, Europe, Africa, and practically all of Asia contain no representatives of this subfamily.

It is not my purpose to sketch the past history of this group, a task recently performed by Seward & Ford, who point out the probable Araucarian affinity of the Paleozoic genera *Walchia*, *Schizodendron* (*Tylodendron*), *Gomphostrobus*, and the possible Araucarian relation of the Triassic genera *Albertia*, *Voltzia*, *Ullmannia*, etc. It is, however, desirable to indicate briefly the probable range of the Araucarieae during the period when the species about to be described flourished, *i. e.*, the Cretaceous.

The recorded occurrences of Araucarieae during the Cretaceous are shown in FIGURE 2. No attempt has been made to revise these data, which may in some instances be based upon insufficient evidence, nor have obviously allied genera like *Brachyphyllum* been included, or any of the many species described as Sequoias, some at least of which would seem to be more properly referable to the Araucarieae.

By referring to the map (FIGURE 2), it will be seen that in the Western Hemisphere we have *Agathis* from 70° north latitude (Greenland), and Araucaria from 40° south latitude (Patagonia), with several species of both genera in the United States, ranging from Block Island to South Carolina on the east coast and from Montana to Kansas in the western interior. In the Eastern Hemi-

* RUMPHIUS, G. E. Herbarium Amboinense 174. Amsterdam, 1741.

† SALISBURY, R. A. Trans. Linn. Soc. Lond. 8: 312. 1807.

sphere we have records as far apart as Spitzbergen (80° North), on the one hand, and Cape Colony (30° South) on the other, with several species of both the *Araucaria* and the *Agathis* type in Europe.

The absence of Asiatic Cretaceous records is to be considered due to the lack of knowledge of Cretaceous plant beds on that continent, and not as indicative of the absence of the Araucarieae at that time.

While the distribution of the recent forms might seem to be an argument for the former existence of Antarctic land connections

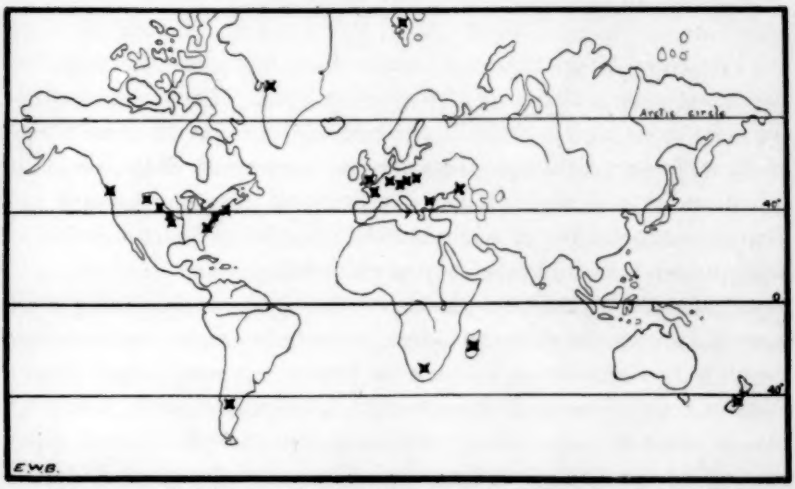

FIGURE 2. Sketch map, showing the recorded occurrences of the Araucariae during the Cretaceous.

and intermigrations, a glance at the fossil record shows that this is not the true explanation of their present occurrence, nor does it, on the other hand, in the least weaken the probability that there was such an Antarctic continent or archipelago, a view with which the writer is in thorough sympathy. In the case of the Araucarieae, however, the records show that a once cosmopolitan group has gradually become extinct in the intervening areas until its present restricted habitats are all that remain of a once world-wide dominance, a dominance which was probably reached during the later Mesozoic.

As a corollary, we would assume that the group is still

dwindling, and this is borne out not only by its much wider range in the Tertiary but by the presence of sub-fossil remains of *Agathis* in New Zealand, and of *Araucaria* in South America, in both cases showing a marked shrinkage in range in very recent times.

During the past two or three years the writer has come into possession of a considerable quantity of Araucarian remains from the Atlantic coastal plain. These are all of Mid-Cretaceous age and it seems desirable to place them on record at the present time since unquestionable remains of the genus *Araucaria* have not been previously recorded from this general region and the final treatment of these South Atlantic Cretaceous floras will undoubtedly take a long time.

The New Jersey material comes from beds of the Magothy formation, very probably of Cenomanian age. The Carolina forms are from beds which differ in age but slightly if at all from those of New Jersey, although they may be somewhat older, possibly synchronous with the Raritan formation of New Jersey and the Tuscaloosa formation of Alabama, the question of exact correlation being under active investigation at the present time.

Evidences of the abundance of the Araucarieae, using that term in a somewhat extended sense, have been emphasized recently through the studies of Hollick & Jeffrey * upon Staten Island material; and Seward & Ford † in their most admirable sketch of the recent and past history of this group have furnished good ground for the belief that the Araucarieae are the most abundant type of Coniferales in the Older Mesozoic.

Following is a brief discussion of the hitherto unknown Atlantic coastal plain species:

Araucarites Zeilleri sp. nov.

Cone a prolate spheroid, about 9 × 7 cm.; scales numerous, long, narrow, thick; cone-axis stout; details of structure obscured. (PLATE 11, FIGURE 3.)

At the first glance this looks like a very beautifully preserved Araucarian cone, but closer inspection shows that poorness of preservation has obscured nearly all of the details of structure,

* HOLLICK & JEFFREY, American Naturalist **40**: 189–216. 1906.
JEFFREY, Bot. Gaz. **44**: 435–444. *pl. 28–30.* 1907.

† SEWARD & FORD, Philos. Trans. Roy. Soc. Lond. **198 B**: 305–411. 1906.

megascopic as well as microscopic. The specimen consists of about one half of a flattened cone, diagonally fractured in a plane not greatly inclined to the longitudinal axis, the latter being hidden distally by the cone-scales and weathered away proximally.

This cone was evidently lignified in the clays and subsequently penetrated peripherally by pyrite for a distance of about 1.5 cm., which, while serving to hold together the much cracked and dessicated interior, also effectually obscures the surface features. It was found among the shingle at low tide on the beach at Cliffwood Bluff, N. J., having been washed out of a body of clay which makes the floor of the beach at this point, and was broken when found, no trace of the other half having been seen.

The specimen is 9.3 cm. long, 7.8 cm. wide at right angles to the flattening force, and 2.5 cm. thick, so that in life the cone must have been almost spherical — a slightly prolate spheroid. The scales were numerous, comparatively long and slender, and the cone-axis was very stout.

In this connection a number of fossils of a more or less doubtful nature from this locality suggest themselves as of Araucarian affinities, notable among which are the leafy twigs referred to Presl's genus *Cunninghamites*, so named for their resemblance to the existing genus *Cunninghamia*, and usually referred to the Taxodieae, although in Zittel's Handbuch (abth. 2, 1890) they are placed by Schenk in the Araucarieae. Two species have been recorded from this locality, *Cunninghamites elegans* (Corda) Endl. and *C. squamosus* Heer, both suggesting Araucarian foliage of the type found in the *Eutacta* section of the genus *Araucaria*. The broad-leaved type of foliage of the subgenus *Columbea* is probably also present at Cliffwood Bluff in the species *Araucarites ovatus* Hollick, to which I will refer on a subsequent page.

Other doubtful remains from this locality which are suggested as possibly of Araucarian affinities are the fossils denominated *Microzamia* (?) *dubia* Berry * and supposed to represent the central axis of a cycadaceous fruit-spike. This might well represent the axis of an Araucarian cone like the one under discussion, more especially as the scales are shed at maturity (in the recent species at least); the small prominence in the spirally disposed pits of the

* BERRY, Bull. Torrey Club **32**: 43. *pl. 1. f. 2.* 1905.

specimen would then represent the single vascular bundle which passed into the base of the scale. This object is now refigured (PLATE 11, FIGURE 1).

Another problematical fossil which may possibly belong to the Araucarieae is the cone previously described simply as "gymnospermous cone" Berry * and refigured on PLATE 11 (FIGURE 2). This might be a staminate Araucarian strobilus, for while most of the modern Araucarieae have greatly elongated staminate strobili, they become shortened and subcylindrical in some species, as for example in *Araucaria excelsa*, the Norfolk Island pine and more particularly in the genus *Agathis* (*Dammara*).

Araucarites Zeilleri may be compared with the cone described by Velenovsky from the homotaxial deposits (Cenomanian) of Bohemia under the name of *Araucaria bohemica*,† which is seen to be similar in appearance, and to the several species of cones of *Araucaria* and *Pseudo-araucaria* which have been described by Fliche from the Albien of France (Bull. Soc. Sci. Nancy, 171–195. *pl. 5. f. 4, 5; pl. 6. f. 2-5; pl. 7. f. 1, 2.* 1896).

Nothing similar has heretofore been collected at Cliffwood Bluff, where so many coniferous remains have been found, and it is of especial interest in coming after the recent announcement by Hollick & Jeffrey (*loc. cit.*) of two types of *Araucarioxylon* lignite from the not distant and possibly homotaxial horizon at Kreischerville, Staten Island,‡ one type which they have correlated with *Brachyphyllum* twig-impressions and with *Protodammara* cone-scales and the other more like recent Araucarian wood — which might well represent the present species — with resinous tracheids, no traumatic resin canals, and with a large pith composed mainly of tanniniferous cells. It has seemed best to use the generic term *Araucarites* as one which is of broader significance than *Araucaria*, since the preservation of the cone is such that it might equally well be considered as a Mid-Cretaceous representative of the allied genus *Agathis* (*Dammara*).

* BERRY, *loc. cit.* 31: 72. *pl. 4. f. 7.* 1904.

† VELENOVSKY, Květena českého cenomanu, 8. *pl. 1. f. 20–24.* 1889.

‡ The major part of the Kreischerville deposit is of Raritan age but there is some evidence that the leaf-bearing layers may be later.

Araucaria bladenensis sp. nov.

Foliage dense; phyllotaxy spiral; leaves decurrent, coriaceous, ovate-lanceolate, about 1.6 × .8 cm., the base rounded, apex thickened, cuspidate; veins immersed, averaging 16 in number, straight, parallel; stomata small, in rows on ventral surface. (PLATES 12 AND 13; PLATE 14, FIGURES 1–3.)

Leaves ranging from 1 to 2.8 cm. in length by .5–1.2 cm. in width, averaging 1.6 by .8 cm., obovate in outline, with a broad rounded base narrowing abruptly and decurrent; the blade broadest about one third of the distance from the base, above which point it narrows rapidly to a thickened cuspidate tip; phyllotaxy spiral; leaf-substance represented by a thick sheet of lignite about .5 mm. thick, in which the veins are immersed. These veins average 14 to 16 in number, although occasionally there may be as many as 20; they are stout, incurved at the base (forking not observed), becoming parallel and running directly upward until they abut against the leaf margin, *i. e.*, not convergent toward the tip of the leaf. When this species was first collected it was thought that it might be sufficiently well preserved to show the internal structure when studied by the admirable methods devised by Professor Jeffrey for treating more or less refractory remains of this sort. Professor Jeffrey, who has been good enough to examine some of these leaves for me with this end in view, writes that in spite of their hopeful megascopic appearance their microscopic structure is not preserved.

In one or two instances where the specimens are in a more argillaceous matrix it has been possible to get rather inferior specimens showing the arrangement and outlines of the stomata (PLATE 14, FIGURE 3). These are broadly ovate in shape with very thin guard cells (at least when viewed on the surface). They are arranged in somewhat irregular rows on the ventral surface of the leaf, the number of rows between the two veins being usually four. Aside from the foregoing facts, the preservation is such that no other details can be made out.

This species is most remarkably similar to the recent *Araucaria Bidwilli* of the Australian region, a twig of which, kindly furnished by the New York Botanical Garden, has been photographed and introduced on PLATE 15 for comparison. The resemblance is even closer than the reproductions indicate, a dried herbarium specimen

of the latter and a twig of the former preserved as a brownish impression in the Rockfish Creek clays being practically indistinguishable. This resemblance in form, habit, and stomatal characters, reinforced by the occurrence of characteristic Araucarian cone-scales in the same beds at certain localities, renders the identification reasonably conclusive.

A wide comparison has been made with other and similar fossil remains of Mesozoic age. The most nearly related form seems to be *Araucarites ovatus* (PLATE 14, FIGURES 4, 5) described by Hollick * from the Cliffwood clays of New Jersey, which differ merely by their larger size, absence of basal characters, and much less pointed tips; in fact, if the two were found in closer association or if in the abundant Carolina material any specimens had approached *Araucarites ovatus* in size I would be disposed to consider them as the variants of a single species. As the case stands, it seems better to institute a new species, since the leaves in the Carolina material are sufficiently and uniformly different enough to be readily recognized, and there is the further possibility that the New Jersey species may be more or less closely related to the modern genus *Agathis* (*Dammara*) rather than to *Araucaria*.

A genus which was at once suggested for comparison was the genus *Nageiopsis* of Fontaine, the real botanical position of which is so uncertain. It is true that Fontaine characterizes the leaf-arrangement as distichous or subdistichous, but this is the ordinary habit of numerous conifers with a spiral phyllotaxy and one which would be emphasized in fossil remains preserved as impressions. There is some resemblance to *Nageiopsis ovata* Font.† from the Older Potomac of Virginia. However, an examination of the type material in the U. S. National Museum demonstrates the distinctness of the Carolina species, as it does also the exceedingly inaccurate figures of Fontaine's monograph. Another of this author's species which is somewhat similar is *Nageiopsis montanensis*, described from the Kootanie of Montana, ‡ but since it is founded on a single specimen and there are no features which indicate that

* HOLLICK, Trans. N. Y. Acad. Sci. **16**: 128. *pl. 12. f. 3a, 4.* 1897.

† FONTAINE, U. S. Geol. Surv. Monog. **15**: 199. *pl. 77. f. 4; pl. 80. f. 5.* 1889.

‡ FONTAINE, *loc. cit.* **48**: 312. *pl. 73. f. 10.* 1906.

it really is a *Nageiopsis*, it is not worth considering further in this connection.

A European form which must surely be considered as a nearly related congener of *Araucaria bladenensis* is Saporta's *Araucaria Toucasi* described from the Turonian of Beausset near Toulon, France.* This is strikingly similar to the Carolina species in every respect and likewise closely allied, in appearance at least, to the recent *Araucaria Bidwilli* of Australia.

Kerner † records *Pachyphyllum* (*Pagiophyllum*) *rigidum* Saporta and *Pachyphyllum* (*Pagiophyllum*) *araucarinum* Saporta from the Cenomanian of Lesina, an island in the Adriatic off the coast of Dalmatia, both being originally Jurassic species from the French Corallien of Verdun ‡. Both are very similar to the Carolina species and are of about the same age. The probable identity of Cenomanian and Corallian species, it seems to me, is extremely doubtful, and both of Kerner's species should undoubtedly be considered as new species of Araucaria and nearly related, if not identical, with such Mesozoic forms as *Araucaria bladenensis* or *Araucaria Toucasi*.

Other fossil remains which deserve to be mentioned in this connection and which may really be Araucarian, although abundantly distinct from this Carolina species, are *Podozamites? acutus* Saporta § from the Neocomian of Portugal, whose resemblance to *Nageiopsis ovata* and *N. zamioides* is noted by Saporta; and *Podozamites lanceolatus* (L. & H.) F. Braun forma *elliptica* Möller from Bornholm ‖ which is scarcely to be distinguished from *Nageiopsis montanensis* Font. from the Kootanie; and *Pagiophyllum* sp. Dawson ¶ from the Kootanie of Canada.

Araucaria bladenensis occurs abundantly as detached leaves in the Cretaceous dark-drab, very lignitic clays, at numerous localities in the south Atlantic Coastal plain, and occasionally as twigs of considerable size showing phyllotaxy and other characters. It is preëminently the type fossil of the Bladen formation of North Caro-

* SAPORTA, Le Monde des Plantes 198. *f.* 27. 1879.

† KERNER, Jahrb. k.k. Geol. Reichsanst. **45**: 49. *pl.* 4. *f.* 3; 50. *pl.* 4. *f.* 1

‡ SAPORTA, Plantes Jurassiques, Paléont. Franc., Végétaux, *pl.* 177, 178.

§ SAPORTA, Fl. Foss. Portugal 87. *pl.* 16. *f.* 28. 1894.

‖ MÖLLER, Kongl. Sv. Vet.-Akad. Handl. **36**[6]: 8. *pl.* 7. *f.* 9. 1903.

¶ DAWSON, Trans. Roy. Soc. Can. **10**[4]: 90. *f.* 14. 1892.

lina,* single leaves or even fragments being quite characteristic and easy of recognition. Discovered originally in material collected at Parker Landing by Dr. L. W. Stephenson in 1906, it has since been found in a large number of outcrops of this formation in this same general region.

Following are the localities from which it is known at the present time:

NORTH CAROLINA: Parker Landing, Tar River (abundant); 95½, 92, 87⅝, and 87½ miles above Newbern, Neuse River; Big Bend (abundant), Sykes Landing, Clear Run, Corbits (Old Union) bridge, A. C. L. R. R. bridge, Horrel Landing, and 74¾ miles above Wilmington, Black River; Rockfish Creek, near Hope Mills (abundant); mouth of Harrison's Creek, Cape Fear River.

SOUTH CAROLINA: 3 to 4 miles northeast of Florence.

ALABAMA: 2 miles south of Havana in Hale County.

Araucaria Jeffreyi sp. nov.

Cone-scales deciduous, rhomboidal, straight-sided, thin-margined, the apex broadly rounded, with long central apical spur; scales divided by transverse furrow into "ligule" and scale proper, single-seeded. (PLATE 16.)

This species is represented by a considerable number of large single-seeded cone-scales preserved as impressions and associated with *Araucaria bladenensis* at Big Bend and A. C. L. R. R. bridge on the Black River, at 92 and 87⅝ miles above Newbern on the Neuse River and at Parker Landing on the Tar River, all localities in North Carolina. The latter specimens differ somewhat from the others and approximate more nearly the shape of the foliage leaves of *Araucaria bladenensis*, but since the scales from the former locality are somewhat variable, as indeed they are from different positions on a single modern Araucarian cone, it seems likely that they all belong to one species of cone.

The scales are rhomboidal, the thin lateral margins straight to the point of greatest width, then more or less rounded, produced medianly into a long and narrow point. This point is over a centimeter long in two specimens which still lack the terminal portion. In some specimens the scales are obviously divided by a

* STEPHENSON, Johns Hopkins Univ. Circulars, II. 1907[7]: 95. 1907.

transverse furrow into the scale proper and the so-called "ligule." This feature is not shown in FIGURES 10 and 11, which probably represent the transitional phase between functional scales and foliage leaves toward the base of the cone, while the additional variations in the specimens figured are probably likewise correlated with the regions of the cone from which they came. They are all preserved as impressions with fragments of lignite representing the scale-substance. With the exception that they do not appear to have been as thick, they are strictly comparable with the typical scales of *Araucaria Bidwilli*. In general outline they are also comparable with the scales of *Araucaria Cookii* of the *Eutacta* section of the genus. Although no seeds have been found as yet in the Carolina material, it seems likely that they will eventually be discovered. From the structure as disclosed in the present impressions it seems obvious that the scales were single-seeded as in the modern genus, and, taken in conjunction with the foliage just described as *Araucaria bladenensis*, they furnish conclusive evidence of the abundant presence in the Mid-Cretaceous of eastern North America of true Araucarieae, thus still further increasing the parallel between the Mid-Cretaceous floras of this country and those of Europe.

Many remains of cones and cone-scales have been described as species of Araucarieae but it seems scarcely worth while to enumerate them in this place. Some have already been mentioned under *Araucarites Zeilleri*, and for others the reader is referred to the monograph of Seward & Ford (*loc. cit.*).

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Explanation of plates 11-16

PLATE 11

FIG. 1. *Microzamia* (?) *dubia* Berry. A possible Araucarian cone-axis, Cliffwood, N. J.

FIG. 2. Gymnospermous cone, Berry. A possible Araucarian staminate cone, Cliffwood, N. J.

FIG. 3. *Araucarites Zeilleri* Berry, sp. nov. Cliffwood Bluff, N. J.

PLATE 12

Araucaria bladenensis Berry, sp. nov.

FIGS. 1–3. Rockfish Creek, N. C.

FIG. 4. Horrel Landing, N. C.

PLATE 13

Araucaria bladenensis Berry, sp. nov. Showing form of detached leaves and their usual method of occurrence. Parker Landing, N. C.

PLATE 14

FIGS. 1, 2. *Araucaria bladenensis* Berry, sp. nov. Showing closely imbricated leaves at the fork of a branch. Parker Landing, N. C.

FIG. 3. *Araucaria bladenensis* Berry, sp. nov. Showing form and arrangement of the stomata, enlarged about 20 times. Rockfish Creek, N. C.

FIGS. 4, 5. *Araucarites ovatus* Hollick. Introduced for comparison. (After Hollick.) Cliffwood Bluff, N. J.

PLATE 15

Araucaria Bidwilli Hook. From a photograph (natural size) of an herbarium specimen. Introduced for comparison. Photograph by E. H. Sapp.

PLATE 16

Araucaria Jeffreyi Berry, sp. nov.

FIGS. 1–9, 12. Big Bend, N. C.

FIGS. 10 11. Parker Landing, N. C

Notes on Carex — IV

KENNETH KENT MACKENZIE

CAREX PHAEOCEPHALA Piper

Carex leporina var. *Americana* Olney, Proc. Am. Acad. Arts & Sci. **8**: 407. 1872 (name only). — Bailey, Proc. Am. Acad. Arts & Sci. **22**: 152. 1886.

"*Carex leporina* L." Bailey, in Coulter, Man. 396. 1885.

"*Carex Preslii* Steud." Bailey, Mem. Torrey Club **1**: 52. 1889.

"*Carex petasata* Dewey;" Holm, Am. Journ. Sci. IV. **16**: 20. 1903.

Carex phaeocephala Piper, Contr. U. S. Nat. Herb. **11**: 172. 1906.

Clumps from medium-sized to large, strongly cespitose, the rootstocks densely matted, the culms 1–3 dm. high, exceeding the leaves, obtusely angled below, sharply angled and more or less roughened above. Leaves three to six to a culm, clustered towards the base, the sheaths much overlapping, whitish-hyaline towards apex opposite the blades, the blades short, more or less involute, ascending to recurving, 1.5–2 mm. wide, usually 5–15 cm. long, roughened towards the apex; spikes two to five (rarely seven) aggregated into an erect head 12–25 mm. long, 5–12 mm. wide, the lower one or two spikes occasionally a little separate, the spikes ovate to oblong, 6–12 mm. long, 5–8 mm. wide, obtuse at apex, narrowed and often quite clavate at base (especially the uppermost), the perigynia usually 10–20, appressed-ascending, the beaks inconspicuous, the staminate flowers basal, inconspicuous; lower bracts occasionally developing a short cusp, the upper scale-like; scales ovate, acute, dark-brownish or brownish with lighter midrib and broad hyaline margins, as wide and as long as the perigynia; perigynia oblong-ovate, flat, plano-convex, distended over the achene, 4.5 mm. long, 1.8 mm. wide, winged, round-tapering at base, strongly nerved on outer surface, nearly nerveless or lightly nerved on the inner, the body abruptly contracted into the beak, which is 1 mm. long, rather minutely bidentate and serrulate on the margins; achenes lenticular, brownish, obovate-oblong, 1.5 mm. long, 1 mm. wide; stigmas two.

This species, which is closely related to *Carex leporina* L., and represents it in the Rocky Mountain region, has been known under

different names for many years, but has never been fully described. Collections made during the last ten years have much extended our knowledge of the plant, and have shown that it has a wide range, and is one of the characteristic species of the alpine summits of the Rockies. The chief distinctions between it and *C. leporina* may be contrasted as follows:

Culms 1–3 dm. high, the leaves bunched near base; blades 1.5–2 mm. wide, more or less involute. *C. phaeocephala.*

Culms 1.5–4 dm. high, the leaves not bunched; blades 2–3 mm. wide, flat. *C. leporina.*

Two names have been ascribed to this species at different times, but neither of them can properly be used.

1. *Carex Preslii* Steud. Plant. Cyp. 242. 1855. The author of this species based his description on Presl's *C. leporina* L. (Reliq. Haenk. 204. 1830). His description can be applied to several North American species of *Carex* found in the Nootka Sound region, where the plant was obtained, and to apply it to the present plant is pure guess-work. It is to be noted, too, that he does not place the species next to *Carex leporina*, which was, of course, well known to him, but in a section "species quoad sectiones et affinitatem minus notae, partim omnino dubiae." The original specimen seems to have disappeared (Bailey, Mem. Torrey Club 1: 52), and, in any event until it is located, the name should be disregarded.

2. *Carex petasata* Dewey, Am. Jour. Sci. I. 29: 246. 1836. As this is one of the earliest published species of *Carex* from the Rocky Mountain region its identification is important. Of it Professor Bailey says: "The original sheet is in Herb. Torr. It contains three plants: *C. lagopina* Wahl., *C. festiva* Dewey, and *C. Liddoni* Boott, to all of which Dewey's description will equally apply" (Mem. Torrey Club 1: 52). Concerning this I should say that the description calls for a plant with a "compressed," "slightly winged" perigynium, characters hardly applicable to *C. lagopina*, and as Dewey described *C. festiva* in the same paper we can hardly refer *C. petasata* to it. The facts concerning this sheet seem to be that Drummond, the original collector, mixed *C. petasata* and *C. lagopina* (Torrey, N. Am. Cyp. 393) and that the specimen of *C. festiva* on the sheet, which was col-

lected by Nuttall, is a later addition. But finally, and most important of all, Dewey's description is accompanied by a plate (*W. f. 72*). This plate clearly shows that it was the third plant on the sheet in the Torrey herbarium which Dewey had in mind. This plant, which I have examined, is *Carex Liddoni* Boott, as stated by Professor Bailey. As this last-named species was not published until 1840 (Hook. Fl. Bor.-Am. **2**: 214) it should be superseded by *Carex petasata* Dewey. The identification of *C. petasata* with *C. phaeocephala* rests on work done when our western *Carices* were but little known, and is entirely baseless, so far as I know.

Of *Carex phaeocephala* I have seen the following specimens:

WYOMING: Big Horn Mts., 7000–9000 ft., *Tweedy 3344*, July–August, 1900; Sheep Mt., 11,000 ft., *Tweedy 410*, August, 1897; Teton Mts. (timber line and above), *A. & E. Nelson 6539*, August 16, 1899; Big Horn Mts., Sheridan County, 10,000 ft., *Tweedy 2240*, August, 1899; Anita Peak, Routt County (alpine grassy summits), *Goodding, 1754*, August 3, 1903; Ethel Peak, Larimer County, *Goodding 1900*, August 14, 1903.

COLORADO: Bottomless Pit, 3800 m., *F. E. & E. S. Clements 501*, July 23, 1901; Windy Point, Pike's Peak, *Clements 3*, 1900; "Rocky Mts.," *Vasey 600*.

UTAH: Belknap Peak, *Rydberg & Carlton 7361*, July 28, 1905; Bear River Canyon, 11,000 ft., *Watson 1234*, August, 1869.

MONTANA: Long Baldy, Little Belt Mts., 7000 ft., *Rydberg 3399* and *3400*, and *Flodman 312*, August 19, 1896; Old Hollowtop (near Pony), 9000 ft., *Rydberg & Bessey 3783*, July 7, 1897; Columbia Falls, *Williams*, September 8, 1892; Spanish Peaks, Madison Range, 7000–8000 ft., *Flodman 323*, July 14, 1896; Spanish Basin, *Rydberg 3066*, July, 1896; Mt. Henry, Midvale, *Umbach 408*, July 16, 1903; near Glacier Basin, 2200 m., *Vreeland 1085*, August 5, 1901 (blades but 1 mm. wide).

IDAHO: Mt. Chauvet, 10,000 ft., *Rydberg & Bessey 3782*, July 29, 1897.

WASHINGTON: Mt. Adams, *Howell, 3900*, August, 1882.

OREGON: Mt. Hood, *Lloyd*, July 21, 1894, and *Henderson* (alpine moraines), July 20, 1884; head of Wallowa River, 9000 ft., *Cusick 2479*, July 17, 1900.

CALIFORNIA: Mt. Shasta, 10,400 ft., *Copeland 3568*, July 16, 1903.

CANADA: Selkirks, 7,500 ft., *Shaw 1020*, July 26, 1905; Selkirks, 8000 ft., Heights above Carbonate Draw, *Petersen*, July 14, 1904; Lake O'Hara, Rocky Mt. Park, 7500 ft., *John Macoun 64016*, August 9, 1904; Lake Louise, Rocky Mts., 7300 ft., *John Macoun 64017*, July 20, 1904; Old Glory Mt., 6500 ft., between Kettle and Columbia Rivers, *J. M. Macoun 63324*, August 13, 1902.

Carex projecta sp. nov.

"*Carex cristata* Schwein." Kunze, Car. *pl. 44. f. g.* 1840–1850. — Boott, Ill. Car. 117, in part, *pl. 373*.

Carex lagopodioides var. *moniliformis* Olney, Exsicc. fasc. 2, no. 8 (n.n.); Bailey, Bot. Gaz. **10**: 380. 1885.

"*Carex tribuloides moniliformis* (Tuckerm.) Britton;" Britt. & Brown, Ill. Fl. **1**: 356. 1896. Not *Carex scoparia* var. *moniliformis* Tuckerm.

Carex tribuloides var. *reducta* Bailey, Proc. Am. Acad. Arts & Sci. **22**: 148. 1886. Not *Carex reducta* Drejer.

Clumps small to medium-sized, not stoloniferous, the culms 5–9 dm. high, exceeding the leaves, strongly roughened on the angles beneath the head. Leaves with well-developed blades usually four to six to a fertile culm, on the lower half but not clustered, the sheaths long and loose, the ligule not prolonged, the blades flat, 3–7 mm. wide, usually 2–4 dm. long, roughened especially on the margins and towards the apex; sterile culms very leafy; spikes eight to fifteen, alternately and usually loosely arranged in a flexuous moniliform head 3–5 cm. long, less than 1 cm. broad, the spikes orbicular or suborbicular, 5–8 mm. long, 4–7 mm. wide, straw-colored or greenish or even brownish, blunt at the apex, subclavate-tapering at base, the staminate flowers basal, few, but their scales rather conspicuous, the perigynia 15–30, ascending-spreading, with conspicuous often widely divergent beaks; lower bract (when developed) setaceous and much shorter than the head; upper bracts scale-like; scales lanceolate or ovate-lanceolate, obtuse to acutish, straw-colored with hyaline margins, often brownish-tinged, narrower and much shorter than the perigynia; perigynia straw-colored or brownish, lanceolate, flat, more or less strongly distended over the achene, noticeably but narrowly wing-margined to the base, 3.25–5 mm. long, about 1.5 mm. wide, nerved on both surfaces, round-tapering at base, tapering into the serrulate bidentate beak, which is one third to one half the whole length; achenes lenticular, short-stipitate, 1.5 mm. long, 0.5 mm. wide, oblong; stigmas two.

This plant is so widely distributed and well marked that it seems to me to be fully entitled to specific recognition. The flexuous head and the small spikes, with the perigynia-beaks conspicuous and widely divergent, present a marked contrast to the stiffer head, the larger spikes, and the appressed perigynia-beaks of *Carex tribuloides* Wahl., its nearest ally. It ranges from Nova Scotia and New Brunswick to Minnesota and south to the District of Columbia and Illinois, but is rare in the southern part of its range. The following specimens have been examined by me:

NOVA SCOTIA: Pictou, *Howe & Lang 459*, July 12, 1901.

NEW BRUNSWICK: Kouchibougnac, *Fowler*.

QUEBEC: Montmorenci Falls, *John Macoun 67783* and *67784*, July 7 and June 28, 1905; Rivière du Loup, *Eggleston 3065*, August, 1902.

MAINE: Ft. Kent, *Knight*, August 20, 1905; Beech Hill Road, Mt. Desert Island, *Faxon*, July 4, 1892; Orono, *Briggs*, September, 1892, and *Fernald*, July 7, 1891; Ft. Fairfield, *Fernald 162*, July 6, 1893.

NEW HAMPSHIRE: "State Line," *Brainerd*, July 16, 1896; White Mountains, *Tuckerman*.

VERMONT: Rutland, *Eggleston 2492*, July 23, 1901.

NEW YORK: Adirondack Mts., *Peck*.

ONTARIO: North Bay, Lake Nipissing, *Fowler*, July 18, 1891; Guelph, *Klugh*, July 25, 1905; Ottawa, *John Macoun 26856*, June 26, 1900.

MINNESOTA: Milaca, Mille Lacs Co., *Sheldon*, July, 1892.

ILLINOIS: Athens, Menard County, *E. Hall*, June, 1870.

DISTRICT OF COLUMBIA: *Steele*, June 3, 1900.

Carex chihuahuensis sp. nov.

Clumps medium-sized, the rootstocks long-creeping, culms 2–3 dm. high, filamentose at base, strict, slightly roughened on the angles, exceeding the leaves. Leaves with well-developed blades four to eight to a fertile culm, clustered on the lower fourth, the sheaths overlapping, the ligules not prolonged, the blades flat, ascending, 2–3 mm. wide, 5–15 cm. long, very rough towards the apex; inflorescence consisting of numerous scarcely distinguishable spikes densely aggregated (or the lower clusters separate) into a compound or somewhat decompound ovate or oblong head, 2–7 cm. long, 7–15 mm. wide, the individual spikes with 4–10 as-

cending or more or less spreading) perigynia below and the inconspicuous staminate flowers above; bracts scale-like, the lower prolonged, shorter than the head; scales ovate-oblong, obtuse (or lower acute), light-brownish with straw-colored midrib and hyaline margins, about the width of the perigynia but shorter; perigynia ovate, plano-convex, thick and corky at base, 3.5 mm. long, 1.5 mm. wide, the edges sharp-angled but not winged, nerved on outer, nerveless on inner surface, at maturity round-truncate at base (the young perigynia rounded), tapering at apex into the serrulate bidentate beak, this $\frac{1}{4}$–$\frac{1}{3}$ the length of the whole (or longer in the young perigynia); achene lenticular, occupying upper half of perigynium body, sessile, oval, 1.5 mm. long, 1 mm. wide; stigmas two.

This is one of the numerous forms at various times referred to *Carex marcida* Boott. The most satisfactory point of distinction between the two species is that the present species has the body of the perigynium corky at base, with the achene in the upper part, while in *C. marcida* the perigynium body is not corky at base and the achene is inserted in the lower part of the body.

Specimens examined:

CHIHUAHUA, MEXICO: Puerta de St. Diego, 6500 ft., *C. V. Hartman 620*, April 12, 1891 (type in herb. N. Y. Bot. Garden); Sierra Madre near Colonia Garcia, 7800 ft., *Townsend & Barber 19*, June 7, 1899.

CAREX SCIRPOIDEA MICHX. AND ITS ALLIES

Among the most widely distributed of the Canadian species of *Carex* is the well-known *Carex scirpoidea* Michx. Found in mountainous country, it ranges from the Gaspé region to the Canadian Rockies and northward to Alaska, and in the United States it occurs in many places in the extreme north — for example, in Maine, New Hampshire, Vermont, and Montana. In the eastern part of its range it has no near relatives, but in western Canada and the northwestern part of the United States, it is either wholly or largely supplanted by certain allied species, several of which have a much more southern range than *Carex scirpoidea* itself.

Of the five allied species which I have been able to recognize, one — *Carex pseudoscirpoidea* Rydberg — has been carefully described by its author; two others — *Carex stenochlaena* (Holm) and *Carex gigas* (Holm) — have been published as varieties of

Carex scirpoidea; and two others — *Carex scabriuscula* and *Carex scirpiformis* — are here proposed as new.

In addition to valuable characters derived from the shape and color of the perigynium and its pubescence or relative lack of pubescence, the chief points connected with the inflorescence to be noticed are the shape, relative length, and pubescence of the scales. The width of the leaf-blades and the relative stoutness of the culms, although at times relied on, are too variable to be of real service, and while the western allies of *C. scirpoidea* as a whole seem much more inclined to grow in dense mats and to have shorter dense rootstocks than that species I am not able to judge from herbarium material alone whether this character can be relied on.

However, there is another character which Mr. Holm has used in other groups of *Carex* and seems to be constant and of value in the present group. That is, in some of the species the lower culm-leaves are reduced to bladeless sheaths, thus leaving in the present group but few (usually 3–5) well-developed leaves to a culm; and in other species the lower culm-leaves develop blades, thus giving in the present group many (usually 6–10) well-developed leaves to a culm. The former species are referred to as aphyllopodic; the latter as phyllopodic. One of the best marks of distinction of *Carex pseudoscirpoidea* is that it is phyllopodic, and this is also true of the very local *Carex gigas* and *Carex scabriuscula*. On the other hand the other three species are aphyllopodic.

The following key will serve to distinguish the species and to contrast their more evident points of difference:

Perigynium sparsely pubescent towards apex only, dark brownish-black.
  Perigynium-body broadly oval, 3 mm. long, very abruptly beaked. *C. gigas.*
  Perigynium-body lanceolate, 4 mm. long, tapering into the beak. *C. scabriuscula.*
Perigynium densely pubescent to hirsute, lighter in color (or dark at apex only).
  Perigynium lanceolate, flattish, 4 mm. long. *C. stenochlaena.*
  Perigynium broader, triangular, 3 mm. long or less.
    Culms aphyllopodic, the culm-leaves usually 3–5; scales shorter than perigynia.
      Scales very minutely hyaline-margined; perigynium whitish-pubescent. *C. scirpoidea.*

Scales very broadly hyaline-margined; perigynium yellowish-hirsute. *C. scirpiformis.*

Culms phyllopodic, the culm-leaves usually 6–10; scales concealing perigynia. *C. pseudoscirpoidea.*

Descriptions of the new species and the varieties here raised to specific rank follow:

Carex gigas (Holm) sp. nov.

Carex scirpoidea var. *gigas* Holm, Am. Journ. Sci. IV. **17**: 21. 1904.

Culms 3–4.5 dm. high, phyllopodic, from densely matted stout rootstocks, the culms stoutish, roughened on the angles above, much exceeding the leaves, reddened and somewhat filamentose at base. Leaves with well-developed blades 5–10 to a fertile culm, clustered near the base, the sheaths hyaline opposite the blades, brownish-tinged and minutely puberulent, the blades ascending, flat, 2.5 mm. wide, 5–15 cm. long, roughened towards the apex; culms dioecious, the spike erect, normally solitary; staminate spike not seen, the pistillate (terminal) linear, 1.5–2.5 cm. long, 4–6 mm. wide, with an ovate short-pointed scale-like bract at base, and an elongated (2–4 cm. long) bract 1–3 cm. below, its sheath slightly darkened and little (1–3 mm.) sheathing, often with a smaller peduncled spike in its axil; scales oblong-ovate, glabrous, brownish with lighter midrib and narrow hyaline margin, acute or obtuse, as wide as the perigynia and of about the same length; perigynia numerous, black, 3 mm. long, 2 mm. wide, the body broadly oval, flattish, rounded at base, rounded at apex and very abruptly contracted into the minute bidentate beak (0.5 mm. long), minutely puberulent above and pubescent on the angles; achenes triangular, 2 mm. long; stigmas three.

This species, as yet known only from northern California, has a perigynium entirely different from that of any other member of this group, and is clearly entitled to be treated as a species.

Specimens examined:

CALIFORNIA: Siskiyou County, 8,000 ft., *Pringle*, August 18, 1881.

Carex scabriuscula sp. nov.

Culms about 3 dm. high, phyllopodic, from stout short-creeping rootstocks, the culms stoutish, roughened on the angles above, much exceeding the leaves, somewhat reddened at base. Leaves with well-developed blades 5–10 to a fertile culm, clustered near the base, the sheaths hyaline, brownish-tinged and minutely puberulent towards the apex opposite the blades, the blades ascending, flat, 2–3 mm. wide, 6–12 cm. long, roughened towards the apex; culms dioecious, the spike erect, normally solitary; staminate spike

not seen, the pistillate (terminal) linear, 1.5–4 cm. long, 4–8 mm. wide, with an ovate short-pointed scale-like bract at base, and an elongated (2–4 cm. long) bract 1–3 cm. below, its sheath somewhat darkened and scarcely sheathing, often with a small peduncled spike in its axil; scales oblong-ovate, glabrous, brownish-black with lighter midrib and narrow hyaline margins, acute or obtuse, as wide as the perigynia but shorter; perigynia numerous, black, 4–4.5 mm. long, 1.5 mm. wide, the body lanceolate, flattish, rounded at base, tapering at apex into the minute entire (or nearly entire) beak (0.5 mm. long), minutely puberulent and pubescent on the angles above; achenes triangular, 2 mm. long; stigmas three.

The perigynium in this plant is so nearly glabrous in age that at a first glance it appears completely so, and this lack of apparent pubescence gives the species a very different aspect from that of *C. scirpoidea*.

Specimens examined:

"Cascade Mountain Plants," wet meadow of the Cascade Mts., *Cusick 2849*, June 30, 1902. (Type in herb. N. Y. Bot. Garden, distributed as *Carex feta* Bailey.)

Carex stenochlaena (Holm) sp. nov.

Carex scirpoidea var. *stenochlaena* Holm, Am. Journ. Sci. IV. **17**: 20. 1904.

Culms 2.5–4 dm. high, aphyllopodic, from densely matted stout rootstocks, the culms stoutish, strongly roughened on the angles above, much exceeding the leaves, reddened and somewhat filamentose at base. Leaves with well-developed blades usually 3–6 to a fertile culm, on the lower third but not clustered, the sheaths long-overlapping, hyaline, brownish tinged and puberulent opposite the blades, the blades ascending, flat, 2–2.5 mm. wide, 5–15 cm. long, roughened towards the apex; culms dioecious, the spike erect, solitary; staminate spike 2 cm. long, 3–5 mm. wide, the scales obtuse, brownish with lighter center and hyaline margins, the pistillate linear, 1.5–3 cm. long, 4–7 mm. wide, with an elongated bract 0.5–5 cm. long, inserted 0.5–3 cm. below, its sheath dark-colored, little sheathing; scales oblong-ovate, puberulent and slightly ciliate at apex, black with midnerve lighter and a very narrow hyaline margin, acute or obtuse, as wide as perigynia but somewhat shorter; perigynia numerous, black (at least towards apex), 4 mm. long, 1.5 mm. wide, the body lanceolate, flattish, rounded at base, tapering at apex into the minute entire beak 0.5 mm. long, appressed-pubescent; achenes triangular, 2 mm. long; stigmas three.

Apparently this species is the most common representative of

the group near the Pacific coast. Its oblong-ovate black scales and long (4 mm.) lanceolate perigynia readily distinguish it.

Specimens examined:

BRITISH COLUMBIA: Chilliwack Valley, 4000 ft., *J. M. Macoun 33,728*, July 12, 1901.

ALASKA: On bluffs along Yes Bay, *Howell 1705 A*, July 16, 1895.

WASHINGTON: Horse-Shoe Basin, Okanogan County, 5000 ft., *A. D. E. Elmer 684*, September, 1897.

Carex scirpiformis sp. nov.

Culms 2.5–4.5 dm. high, aphyllopodic, from matted or short-creeping slender or stoutish rootstocks, the culms from slender to stout, strongly roughened on the angles above, much exceeding the leaves, reddened at base. Leaves with well-developed blades usually 3–6 to a fertile culm, on the lower third but not clustered, the sheaths long-overlapping, hyaline, brownish-tinged and puberulent opposite the blades, the blades ascending, flat, 2–3 mm. wide, 5–20 cm. long, roughened towards the apex; culms dioecious, the spike erect, solitary or rarely with a small additional one at base; staminate spike not seen, the pistillate linear, 2–4 cm. long, 4–5 mm. wide, with a rudimentary or elongated bract 3 cm. or less long at or somewhat below the base, its sheath somewhat darkened, little sheathing; scales ovate, strongly pubescent and ciliate at apex, brownish with broad white-hyaline margin and lighter center, obtuse or acute, as wide and nearly as long as perigynia; perigynia numerous, greenish or yellowish-brown, hirsute, 2.5 mm. long, 1.25 mm. wide, the body ovate-oval, obscurely triangular, tapering to a substipitate base, abruptly contracted at apex into the minute entire beak (0.5 mm. long); achenes triangular, 1.75 mm. long; stigmas three.

This plant is more closely related to *C. scirpoidea* than are any of the other plants here discussed. The contrast, however, between the long scales of this species with their broad hyaline margins, and those of *C. scirpoidea* with nearly no margin and usually much shorter than the perigynia, is so marked and constant in the specimens examined that I feel justified in proposing the species.

Specimens examined:

ALBERTA: Banff, damp ground near Middle Spring, 4700 ft. *McCalla 2348*, July 28, 1899. (Type in herb. N. Y. Bot. Garden); near Banff, *Macoun*, June 30, 1891 (in part); Rocky Mt. Park, *John Macoun 64054*, July 11, 1904.

The water-storing tubers of plants

JOHN W. HARSHBERGER

(WITH PLATE 17)

Recently there has been brought to the attention of the writer a number of plants that produce water-storing organs of an interesting morphologic character. They were examined in the fresh condition in free-hand sections and a number of microchemic tests were applied in order to ascertain the character of the respective reserve materials. Two species of ferns, *Nephrolepis cordifolia* from the garden of Dr. P. P. Calvert and *Nephrolepis davallioides* Kze. [*N. acuminata* (Houtt.) Kuhn] from the fernery of Mr. John P. Morris, of Chestnut Hill, were examined in detail. *Asparagus Sprengeri*, a much cultivated species of asparagus, was also studied.

Nephrolepis cordifolia (L.) Presl. [*N. tuberosa* (Bory) Willd.] is a fern which is often found in cultivation. It is easily mistaken for the sword-fern, *N. exaltata*, but it differs from that fern in having shorter fronds and the pinnules more closely crowded together. It resembles *N. philippinensis* Hort.,* also found frequently in cultivation. *Nephrolepis cordifolia* is said to occur in northern India, Japan, Australia, New Zealand, tropical east and west Africa and in the whole of tropical America, growing on the ground, as well as epiphytic on trees. It has short, thick rhizomes covered by broken-off leaf-bases and numerous strong branches are formed, some of which are developed in midsummer as fleshy tubers which are about the size of pigeon-eggs (PLATE 17, FIGURE 1). More exactly, a mature tuber measured by me was in three dimensions, twelve millimeters, twenty-eight millimeters, and three millimeters. Christ† states that these tubers store reserve products of use to the plant in its epiphytic existence. Mrs. J. M. Milligan‡ of Jacksonville, Florida, found tubers on a specimen of

* BAILEY, in the Cyclopedia of American Horticulture, gives this (*N. philippinensis*) as probably belonging to *N. exaltata*.

† CHRIST. Die Farnkräuter der Erde, 288.

‡ MILLIGAN, Mrs. J. M. Tubers of Nephrolepis. Fern Bulletin 7: 12. 1899.

Nephrolepis, called by her *N. exaltata*, while changing the fern from one pot to another. The tubers, she says, were of all sizes up to three fourths of an inch in diameter and irregularly rounded. No indications of buds were discovered and some of the largest tubers were planted, but did not grow.

In all probability, as pointed out by J. Birkenhead,* the fern described by Mrs. Milligan as *N. exaltata* was *N. cordifolia* (= *N. tuberosa*). *Nephrolepis philippinensis* produces tubers in profusion, so also do *N. Pluma* var. *Bausei* and *N. undulata*, all deciduous ferns. A peculiar feature of these deciduous ferns, Birkenhead states, is that the plant of one season does not always grow again from the old caudex, but there is in many cases a tuber formed close to the old caudex, from which growth commences in due course the following season. The other tubers formed at various distances away from the main stem also commence growth and produce plants. One of the points which distinguish *N. pectinata* from the others, as Clute adds editorially in commenting on Birkenhead's article, is the absence of tubers. *Adiantum diaphanum* (*A. setulosum*) produces tiny tubers on its roots, the size of mustard seeds, some roots bearing twenty to thirty tubers in a length of three to four inches. Velenovsky † in his Vergleichende Morphologie der Pflanzen also describes the tubers of *Nephrolepis cordifolia* (= *N. tuberosa*).

Le Maout and Decaisne mention *Nephrodium esculentum* ‡ of Nepaul that furnishes edible tubers used by the natives. Heinricher, § in a paper published since the above statements were written by me, has presented a complete study of the regeneration of several species of *Nephrolepis* from the fleshy tubers noticed above, when these are cut and experimentally treated. He finds that tubers are formed on *N. cordifolia* Presl (= *N. tuberosa* Presl), *N. hirsutula* (Forst.) Presl, *N. Pluma* Moore, and *N. philippinensis* Hort. He distinguishes two forms of *N. cordifolia*, viz., subspecies

* BIRKENHEAD, J. Tubers of Nephrolepis. Fern Bulletin 7: 35. 1899.

† VELENOVSKY, J. Vergleichende Morphologie der Pflanzen, Teil I. Prag, 1905.

‡ I cannot find this name, but give it as a quotation.

§ HEINRICHER, E. Zur Kenntnis der Farngattung *Nephrolepis*. Flora 97: 43-73. *pl. 1, 2.* 28 D 1906. *N. Pluma* Moore is considered a variety of *N. cordifolia*.

(*a*) *tuberosa* and subspecies (*b*) *etuberosa*. The regeneration from tubers in *N. cordifolia* subsp. *tuberosa*, in *N. hirsutula*, in *N. Pluma*, and in *N. philippinensis* consists in the formation of stolons with a central axial bundle system and normal green pinnae arising from these ramentae-covered stolon-like branches. His photographic illustrations show the character of the various forms of tubers in a very satisfactory manner. Incidentally, Heinricher states that in *N. cordifolia* the tubers serve for the storage of water. In the large parenchyma-cells of the tubers of *N. hirsutula* Heinricher found small starch grains (?), which in no case completely filled the cells, and such cells reacted to Fehling's solution, indicating the presence of sugar. Sperlich likewise claims that he found the cells of young tubers filled with starch, while in the mature tubers the starch grains were sparingly found, but the sugar content had increased proportionately.

My observations on the structure of fern tubers, now to be recorded, are at variance with the above statements in the two species of *Nephrolepis* investigated by me, viz., *N. cordifolia* and *N. davallioides*. In these two ferns, the lateral cord-like branches with small hair-like ramentae are brown in color (PLATE 17, FIGURE 2). These ramentae extend also to the wrinkled surface of the tuber, but are more sparingly found. A microscopic examination of the tuber surface shows that it consists of large epidermal cells, the walls of which interlock by sinuous lines (PLATE 17, FIGURE 3). The interior of the tuber is found to consist of large, rounded hexagonal, or pentagonal parenchyma-cells, with thin walls (FIGURE 4), while the fibrovascular elements are arched near the surface, running from base to apex. These parenchymatous cells in the freshly cut tubers are filled with watery protoplasm, and the observer is impressed by the absence of solid reserve food. Considerable protoplasm with a large nucleus is present in the younger cells (FIGURE 5), but in the older cells the protoplasm and nucleus are confined to a thin wall-layer, as the sap vacuole increases in size (FIGURE 6). Treatment with iodine fails to reveal the presence of starch and protein. Water-eosin colors the protoplasm but slightly, and this reaction, as also the application of Bismarck brown, excludes the possibility of the presence of protein granules, while the use of Fehling's test for sugar gives a decided reaction, if

strong cupric sulphate is used. Absolute alcohol does not cause the deposit of inulin crystals, and the absence of inorganic crystals is very noticeable. Imbedded in the protoplasm of the cells and scattered through it are granules which suggest starch, although the iodine test fails to show its presence in the fresh tubers. To be absolutely sure that these granules were not starch grains, I applied dilute sulphuric acid, washed off the acid with distilled water, and treated the sections with iodine. No reaction took place which would indicate the presence of starch. The presence of tannin, especially in the partially mature tubers, was revealed by the action of the juice on a bright razor blade. The bluish-black discoloration produced showed the formation of tannate of iron. This test is corroborated by a microchemic reaction in which the starch-like granules take part. Tannin vesicles have been observed in various phanerogams. These tannin vesicles always arise, as Klercker has shown, in the protoplasm, from which they are most probably separated by a true precipitation membrane of albumen tannate. Whether they contain other substances than tannins cannot at present be certainly stated. Especially useful in determining the presence of tannin is Pfeffer's staining *intra vitam* with methylene-blue. In a solution of this pigment, the cell sap which contains tannin and the tannin vesicles take up the blue color. This reagent applied to thick sections of *Nephrolepis* tubers produced a blue color in the starch-like granules (FIGURE 7) which had not reacted with the application of iodine, Bismarck brown, water-eosin, sulphuric acid and iodine, and acetic acid. That this test is decisive with reference to these granules is proved, I believe, by the presence of sugar in the older tubers, such sugar having been derived from the stored tannin. It is a known chemical fact that tannin may be converted into sugar by a complex reaction, and in all probability, although I have been unable to prove it, the tannin present in the living parenchyma-cells of the above fern species is slowly transformed into sugar which reacts in the older tubers to Fehling's solution.

The character of the reserve material stored in the tubers having been determined, it can be stated definitely that water storage is the principal function of them. The amount of water stored is very considerable. If a tuber is left in the sun to dry, it loses practi-

cally all of its weight and shrivels up to a small mass of dried material, only one twenty-fifth the size of the original tuber. The observations of Goebel * are *apropos*. Goebel states that he found *Nephrolepis tuberosa* (perhaps *N. cordifolia*) as an epiphytic or terrestrial fern on the road to the Tankoban Prahoe volcano in Preanger, Java. He states that the tubers of this fern, the size of pigeon-eggs, are for the purpose of storing water, for he found that the water content was 96.3 per cent. of the total weight. He further proved this statement by placing tuber-bearing ferns in dry soil. The fronds remained green, although the water supply was extremely small. Gradually, however, the water disappeared from the tubers until they assumed a shrunken form. When grown in wet soil, the tubers retained their normal plumpness. The conclusion reached by Goebel, therefore, was that these tubers are of importance to the fern in tiding over shorter or longer periods of drought.

TUBERS OF ASPARAGUS SPRENGERI

This much-cultivated species of asparagus produces a considerable number of tuberous roots. The large secondary roots are about the thickness of a telegraph wire and on the lateral roots that grow from the larger ones occur the watery tubers † which range from twenty-five to forty-four millimeters in length and from eighteen millimeters in the larger tubers to ten millimeters in the smaller ones. They are light brown in color and almost perfectly smooth. From their distal extremity, the root is continued and this root continuation may branch and rebranch into numerous subsidiary branches.

Sections of these tubers mounted in water show large parenchyma-cells without solid contents, except in a few, small, scattered cells where bundles of raphides occur. With iodine the protoplasm which lines the cell-wall becomes yellow, and the complete absence of starch is also determined by this test. The large nuclei of these cells are also clearly shown when water-eosin is applied. These nuclei lie in the peripheral protoplasm and with the increase in size of the sap vacuole, the nucleus flattens out against the cell-wall in the thin layer of protoplasm remaining. Finally, the

* GOEBEL, K. Pflanzenbiologische Schilderungen I: 203.

† Strictly a tuber is a stem, or branch; I have used the word here in a lax sense.

nucleus disappears and the lining protoplasmic layer becomes still more contracted until it is difficult to detect. Absolute alcohol causes the contraction of the tubers, but no inulin is crystallized out by the use of this reagent. The application of Fehling's solution is without result, nor is tannin present, as the razor and methylene-blue tests indicate. Clearly, we are led to the conclusion that these tuberous roots are developed for the purpose of storing water and the necessity for the storage of this water is the same as in the fern species previously described.

UNIVERSITY OF PENNSYLVANIA.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Atkinson, G. F. Notes on some new species of fungi from the United States. Ann. Myc. **6**: 54–62. 31 Mr 1908.
Includes 27 new species.

Atwood, A. C. Catalogue of the botanical library of John Donnell Smith. Contr. U. S. Nat. Herb. **12**: 1–94. 23 Ap 1908.

Bailey, W. W. Some wild orchids. Am. Bot. **14**: 1, 2. [My] 1908. [Illust.]

Beddome, R. H. *Gesneraceae*, with annotated list of the genera and species which have been introduced to cultivation. Jour. Roy. Hort. Soc. **33**: 74–100. Ja 1908.

Benedict, R. C. Studies in the *Ophioglossaceae* — I. A descriptive key to *Ophioglossum* in the United States. Torreya **8**: 71–73. 30 Ap 1908.

Berger, A. *Opuntia Miquelii* Monv. Monats. Kakteenk. **18**: 35, 36. 15 Mr 1908.

Berry, E. W. A mid-cretaceous species of *Torreya*. Am. Jour. Sci. IV. **25**: 382–386. *f. 1, 2.* My 1908.

Bicknell, E. P. The ferns and flowering plants of Nantucket — II. Bull. Torrey Club **35**: 181–201. 29 Ap 1908.
Includes *Panicum Owenae* and *Elymus halophilus*, spp. nov.

Bolley, H. L. Observations regarding the constancy of mutants, and questions regarding the origin of disease resistance in plants. Am. Nat. **42**: 171–183. [Ap] 1908.

Brainerd, E. *Viola chinensis* in the Eastern United States. Rhodora **10**: 38–40. [Ap] 1908.

Britton, N. L. North American trees. i–x + 1–894. *f. 1–781.* New York. Ap 1908.

Includes the trees found wild north of the West Indies and Mexico, describing new species in *Populus* (2) *Salix*, *Acer* (2), *Fraxinus* (3), and *Acacia*.

Britton, N. L. The genus *Ernodea* Swartz: a study of species and races. Bull Torrey Club **35**: 203–208. 29 Ap 1908.

Includes *E. Millspaughii*, *E. Nashii*, and *E. Taylori*, spp. nov.

Britton, N. L. Wild Jamaica cotton. Science II. **27**: 665. 24 Ap 1908.

Campbell, D. H. Symbiosis is fern prothallia. Am. Nat. **42**: 154–165. *f. 1–3.* [Ap] 1908.

Clute, W. N. A new fern. Am. Bot. **14**: 8–10. [My] 1908. [Illust.]

Clute, W. N. Compass plant fruits. Am. Bot. **14**: 3, 4. [My] 1908. [Illust.]

Collins, J. F. Some mosses from Aroostook County, Maine. Rhodora **10**: 37, 38. [Ap] 1908.

Cook, M. T. The development of the embryo-sac and embryo of *Potamogeton lucens*. Bull. Torrey Club **35**: 209–218. *pl. 9, 10* + *f. a–f.* 29 Ap 1908.

Cook, O. F. Note on Professor Britton's wild Jamaica cotton. Science II. **27**: 665, 666. 24 Ap 1908.

Cushman, J. A. The New England species of *Closterium*. Bull. Torrey Club **35**: 109–134. *pl. 3–5.* 20 Ap 1908.

Includes *C. Novae-Angliae*, sp. nov. from Massachusetts.

Dowell, P. New ferns described as hybrids in the genus *Dryopteris*. Bull. Torrey Club **35**: 135–140. 20 Ap 1908.

Includes *D. Clintoniana* × *intermedia*, *D. Goldiana* × *intermedia*, *D. Goldiana* × *marginalis*, hybb. nov.

Eaton, A. A. Nomenclatorial changes in *Isoëtes*. Rhodora **10**: 42. [Ap] 1908.

Edgerton, C. W. Two little known Myxosporiums. Ann. Myc. **6**: 48–53. *f. 1, 2.* 31 Mr 1908.

Includes *M. corticolum* and *M. longisporum* spp. nov.

Eichlam, F. *Melocactus guatemalensis* Gürke & Eichlam. Monats. Kakteenk. **18**: 37, 38. 15 Mr 1908.
Described as new.

Evans, A. W. *Hepaticae* of Puerto Rico — IX. *Brachiolejeunea, Ptychocoleus, Archilejeunea, Leucolejeunea* and *Anoplolejeunea*. Bull. Torrey Club **35**: 155–179. *pl. 6–8*. 29 Ap 1908.
Includes *Brachiolejeunea insularis* sp. nov.

Evans, A. W. *Lopholejeuna Muelleriana* in Florida. Bryologist **11**: 45, 46. My 1908.

Fobe, F. Einiges über blühende Kakteen. Monats. Kakteenk. **18**: 42–45. 15 Mr 1908.

Foster, A. S. *Polypodium Scouleri*. Muhlenbergia **4**: 21. 14 Ap 1908.

Frič, —. Eine neue Form von *Echinocactus Fričii*. Monats. Kakteenk. **18**: 45. 15 Mr 1908.

Frye, T. C., & Engstrom, E. C. A key to the families of ferns and flowering plants of Washington. 1–19. 1908.

[Gibson, H. H.] American forest trees — 72. Bitternut hickory, *Hicoria minima* Britt. Hardwood Record **25**[12]: 16, 17. 10 Ap 1908. [Illust.]

[Gibson, H. H.] American forest trees — 73. Balsam fir, *Abies balsamea* Linn. Hardwood Record **26**[1]: 16, 17. 25 Ap 1908. [Illust.]

Gifford, J. The names of mahogany. Forestry & Irrig. **14**: 196–198. Ap 1908.

Grout, A. J. Mosses with hand-lens and microscope — IV. 247–318. *pl. 56–75 + f. 134–165*. New York. Ap 1908.

Harper, R. M. Georgia's forest resources. Southern Woodlands **1**[6]: 15–32. F 1908. [Illust.]

Harshberger, J. W. The flora of the Bay of Naples. Old Penn Weekly Review **1908**: 3. 4 Ap 1908.

Hasse, H. E. Lichens collected in the Tehachapi Mountains, California, June, 1907. Bryologist **11**: 55–57. My 1908.

Hay, G. U. Memorial sketch of the late John Moser. Bull. Nat. Hist. Soc. New Brunswick **6**: 46. 1908.

Haynes, C. C. Lucien Marcus Underwood. Bryologist **11**: 41–44. *pl. 4*. My 1908.

Heller, A. A. Two Californian species of *Ribes*. Muhlenbergia **4**: 27–30. 14 Ap 1908.
R. Grantii and *R. purpurascens*, spp. nov.

Houghton, E. M., & Hamilton, H. C. A pharmacological study of *Cannabis americana* (*Cannabis sativa*). Am. Jour. Pharm. **80**: 16–20. Ja 1908.

House, H. D. Studies in the North American Convolvulaceae — IV. The genus *Exogonium*. Bull. Torrey Club **35**: 97–107. *pl. 1, 2.* 20 Ap 1908.
Includes 5 new species from the West Indies and Mexico.

House, H. D. The genus *Rosenbergia*. Muhlenbergia **4**: 22–25. 14 Ap 1908.
Includes *R. Pringlei* sp. nov.

Howe, R. H., & M. A. Common and conspicuous lichens of New England. Part 5. 72–87. Boston. 1908. [Illust.]

Humphrey, H. B. Studies in the physiology and morphology of some California Hepaticae. Proc. Wash. Acad. Sci. **19**: 1–50. *pl. 1, 2.* 18 Ja 1908.

Hus, H. Fasciations of known causation. Am. Nat. **42**: 81–97. [Ap] 1908. [Illust.]

Jackson, H. S. *Sorosporium Ellisii* Winter, a composite species. Bull. Torrey Club **35**: 147–149. 20 Ap 1908.
Includes *S. confusum* sp. nov.

Jeffrey, E. C. On the structure of the leaf in cretaceous pines. Ann. Bot. **22**: 207–220. *pl. 13, 14.* Ap 1908.

Jennings, O. E. A further occurrence of *Wynnea americana* in Pennsylvania. Ann. Carnegie Mus. **4**: 226, 227. *pl. 56.* Ap 1908.

Jennings, O. E. An ecological classification of the vegetation of Cedar Point. Ohio Nat. **8**: 291–340. *f. 1–22.* Ap 1908.

Jordan, D. S. The law of geminate species. Am. Nat. **42**: 73–80. [Ap] 1908.

Knuth, R. Die Gattung *Hypseocharis*. Bot. Jahrb. **41**: 170–174. 24 Mr 1908.
Includes 4 new South American species.

Labroy, O. Les nouveaux maniçobas de Bahia et de Piauhy. Jour. d'Agric. Trop. **8**: 65–71. 31 Mr 1908.

Laumonnier, E. *Ipomopsis elegans*. Rev. Hort. **80**: 108, 109. 1 Mr 1908. [Illust.]

Lemmon, J. G. Notes by a pioneer botanist—I. Muhlenbergia **4**: 17–21. 14 Ap 1908.

Lorenz, A. *Jungermannia* in New Hampshire. Torreya **8**: 55, 56. 27 Mr 1908.

Lorenz, A. Notes on *Jubula pennsylvanica*. Bryologist **11**: 46, 47. *pl. 5*. My 1908.

Maxon, W. R. Studies of tropical American ferns—no. 1. Contr. U. S. Nat. Herb. **10**: i–viii; 473–503. *pl. 55, 56*. 30 Mr 1908.

Includes new species in *Asplenium* (2), *Diplazium*, *Dryopteris* (2), *Elaphoglossum*, *Pellaea*, (2), *Cheilanthes* (2), *Phymatodes*, *Polypodium*, *Stenochlaena*, and *Adiantopsis*, and two new genera, *Holodictyum* (*Asplenieae*), and *Ananthacorus* (*Vittarieae*).

Merrill, G. K. Lichen notes no. 5. Remarks on nomenclature and three new names. Bryologist **11**: 48–53. My 1908.

Mieckley, W. *Opuntia myriacantha* Web. Monats. Kakteenk. **18**: 45, 46. 15 Mr 1908.

Möbius, M. Die Perianthblätter von *Cocos nucifera*. Ber. Deuts. Bot. Gesells. **26a**: 115–124. *pl. 1*. 26 Mr 1908.

Morgan, A. P. North American species of *Agaricaceae*. Jour. Myc. **14**: 64–75. 15 Ap 1908.

Includes *Stropharia drymonia* and *S. micropoda*, spp. nov.

Murrill, W. A. A collection of Philippine polypores. Leaflets Philipp. Bot. **1**: 262–271. 14 Ja 1908.

Murrill, W. A. Collecting and studying *Boleti*. Torreya **8**: 50–55. 27 Mr 1908.

Muschler, R. Die Gattung *Coronopus* (L.) Gaertn. Bot. Jahrb. **41**: 119–147. *f. 1, 2*. 24 Mr 1908.

Nash, G. V. The story of the mangrove. Torreya **8**: 73–78. *f. 1–4*. 30 Ap 1908.

Pammel, L. H. Dr. Edwin James. Ann. Iowa **8**: 161–185; 277–295. 1908 (?).

Pond, R. H. Further studies of solution tension and toxicity in lipolysis. Bot. Gaz. **45**: 232–253. 14 Ap 1908.

Purpus, A. *Yucca valida* Brandegee. Monats. Kakteenk. **18**: 38, 39. 15 Mr 1908. [Illust.]

Quehl, L. *Mamillaria Delaetiana* Quehl, n. sp. Monats. Kakteen. **18**: 59, 60. 15 Ap 1908. [Illust.]

Ramaley, F. Botany of northeastern Larimer County, Colorado. Univ. Col. Stud. **5**: 119–131; i–vi. *f. 1–10*. F 1908.

Ramaley, F., & Robbins, W. W. Ecological notes from north-central Colorado. Univ. Col. Stud. **5**: 111–117. F 1908. [Illust.]

Record, S. J. The forests of Missouri. Southern Woodlands **2**: 10–16. Ap 1908.

Rother, W. Winterbetrachtung über Kakteen. Monats. Kakteenk. **18**: 38, 41, 42. 15 Mr 1908.

Rothrock, J. T. Sweet gum, bilsted (*Liquidambar styraciflua* L.). Forest Leaves **11**: 120. Ap 1908. [Illust.]

Sears, J. H. A southern flora and fauna of post-pleistocene age in Essex County, Massachusetts. Rhodora **10**: 42–46. [Ap] 1908.

Sluiter, C. P. List of the algae collected by the Fishery-Inspection Curaçao. Rec. Trav. Bot. Néerland. **4**: 231–241. *pl. 8.* 1908.
Includes *Zellera Boekii* sp. nov.

Towle, P. M. Notes on the fruiting season of some of the mosses. Bryologist **11**: 53, 54. My 1908.

Transeau, E. N. The relation of plant societies to evaporation. Bot. Gaz. **45**: 217–231. *f. 1–9.* 14 Ap 1908.

Trelease, W. Variegation in the *Agaveae.* Wiesner Festschr. 332–356. *pl. 6–12.* Wien, 1908.

Wakeman, N. A. Phytochemistry in America. Pharm. Rev. **26**: 151, 152. *portrait.* Ap 1908.
Biographical sketch of Helen Cecilia DeSilver Abbott.

Ware, R. A. *Salix incana* at Castine, Maine. Rhodora **10**: 56. [Ap] 1908.

Warnstorf, C. *Sphagnum Faxonii;* an addition to the flora of New England. Rhodora **10**: 40–42. [Ap] 1908.

Warren, A. E. Selecting a microscope. Am. Bot. **14**: 4–7. [My] 1908.

Wester, P. J. The correlation of flower- and fruit-structure in *Carica Papaya.* Bull. Torrey Club **35**: 141–146. *f. 1, 2.* 20 Ap 1908.

White, C. A. The aggregate origination of parasitic plants. Am. Nat. **42**: 98–108. [Ap] 1908.

Williston, S. W. What is a species? Am. Nat. **42**: 184–194. [Ap] 1908.